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WHITE RIVER SHALE PROJECT

Federal Prototype Oil Shale Leases
Ua and Ub

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PROGRESS REPORT

ENVIRONMENTAL PROGRAMS

- 1979 -

WHITE RIVER SHALE PROJECT

FEDERAL PROTOTYPE OIL SHALE LEASES Ua AND Ub

September 1980

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Section 1.0

SUMMARY

This "Progress Report -- Environmental Programs" addresses the work accomplished during the 1979 calendar year (January 1, 1979 through December 31, 1979). The water resources portion, however, is reported on a water year basis (October 1, 1978 through September 30, 1979). During these periods the White River Shale Project continued to collect data on the air, water, and biological resources on and near Federal Oil Shale Prototype Program Lease Tracts Ua and Ub in northeastern Utah. Pertinent data collected by the U. S. Geological Survey and the Bureau of Land Management are also included in this report.

Precipitation for 1979 was slightly above average for the tracts. In fact, this was the wettest year, based upon average precipitation, since the monitoring program began in 1975. Average precipitation was 10.79 inches for the water year. Net evaporation over the period May, 1979 through September, 1979 was 34.32 inches with May being the lowest month and June the highest.

Streamflow in the White River was slightly higher than the preceeding year and was also above the average values for the period of record (1975-1979). The highest and lowest recorded flows at Station 6500 were 3900 cubic feet per second (cfs) and 190 cfs, respectively. Total annual runoff for the 1979 water year was 555,000 acre-feet.

The available data indicate that there was little variation in the physical and chemical composition of the surface water between the White River stations during the 1979 water year, except for suspended sediment values.

The suspended sediment data indicate significantly greater levels at the downstream station, especially during the peak flow period. The measurements at the downstream station appear to have been influenced by local hydraulic conditions (either channel erosion or temporary sediment suspension) which may have increased the suspended sediment concentrations at the sampling location during certain portions of the year.

No significant differences from previous years in either the physical or chemical characteristics of Evacuation Creek were noted during 1979. What differences did exist were caused by the hydrologic system's response to variable climatic conditions.

The air resources monitoring program continued through 1979. One station was used to collect air quality data, while four stations were used to collect meteorological data.

Air quality continued to be good over the tracts during 1979. Instruments measuring carbon monoxide, nitrogen dioxide, and sulfur dioxide recorded concentrations near their detection limit for most of the year. While the National Air Quality Standards (NAAQS) for ozone were not exceeded on the tracts, a trend of decreasing ozone concentrations since 1975 was reversed during 1979. Particulate concentrations continued to decline over the tracts which can be traced, in part, to the decrease in average wind speeds measured at Site A-6. Due to inconsistencies between the NAAQS for non-methane hydrocarbons and the available measurement techniques, values for this parameter are not reported.

The maximum hourly ozone concentraction measured at Site A-6 during 1979 was 151 $\mu g/m^3$ compared to the NAAQS of 235 $\mu g/m^3$. The average one-hour measurements ranged from 63 $\mu g/m^3$ in the Fall to 78 $\mu g/m^3$ during the Winter months.

The maximum hourly suspended particulate concentration was 52.9 $\mu g/m^3$ measured in the Fall, compared with the secondary standard of 150 $\mu g/m^3$. The annual geometric mean was 12.5 $\mu g/m^3$, compared to the secondary standard of 60 $\mu g/m^3$.

Biological resources monitoring continued during 1979 covering both terrestrial vertebrate populations and general vegetation conditions.

Vegetation research during 1979 consisted mainly of monitoring existing field studies to determine the degree of stability achieved in revegetated areas. The growing season of 1979 was average with few extremes of temperature or precipitation. The year yielded better than average biomass production from the various vegetation types. This reflected the favorable rainfall distribution during the mid-year.

Continued sagebrush stem growth provides a biologically-integrated measure of site favorability. The year 1979 reflects moderately favorable conditions for biomass production as growth response during the year was better than any of the previous four years.

Several field studies continued from preceding years during 1979. Studies on the effects of plant competition, plant age at planting, season and methods of planting, and processed shale over-planting are producing valuable results which will greatly aid our revegetation efforts.

Terrestrial vertebrate monitoring during 1979 continued to provide highly variable yet interesting information. Among the mammals, bat populations decreased substantially during 1979 following their peak in 1978. Cottontail rabbit abundance has continued to decline. Rodent density has continued at a low level, attributable to a rather dry spring which inhibited sagebrush growth during that time. Coyotes are the most plentiful carnivore on tracts with about equal numbers of sitings during the years. No gray foxes were

noted on tract during 1979. Mule deer abundance continued to decline, although they were present in all vegetation types. Species richness among birds was low during 1979 while abundance has increased. Riparian areas continued to be the favored habitat.

Among the reptiles, snake abundance, while increasing, remained low, varying in relation to precipitation and rodent populations. Lizard abundance is decreasing slightly on the tracts.

Two of the most important aspects of our five year wildlife monitoring program are the establishment of important parameters and the recognition of baseline conditions. These factors are critical prerequisites to any successful revegetation plan.

In reference to monitoring, wildlife provides three important inputs. The birds follow primary production as it occurs. They are the first indicators of environmental change, fluctuating in direct proportion to plant production. Their response to environmental flux is immediate and as five years have shown, precise. However, since birds are mobile, they merely indicate an immediate change, but cannot be used to determine its magnitude. The magnitude is displayed by the mammals, primarily the small rabbits and rodents. The response of the large mammals is usually confusing, due to their mobility, and measuring their changes is very costly. Rabbits and rodents which are restricted to sensible areas can be measured precisely and at low costs. The reptiles, especially the lizards, add an extra dimension to desert system monitoring. On the tracts they have remained the most stable vertebrate class in terms of species and abundance through drastic climatic changes. Should their kinds and numbers begin fluctuating like the birds or mammals, some man-induced change will be the most likely cause.

Our environmental monitoring plans for 1980 will be essentially the same as 1979 in anticipation that development of the tracts will soon be reinitiated.

Section 2.0

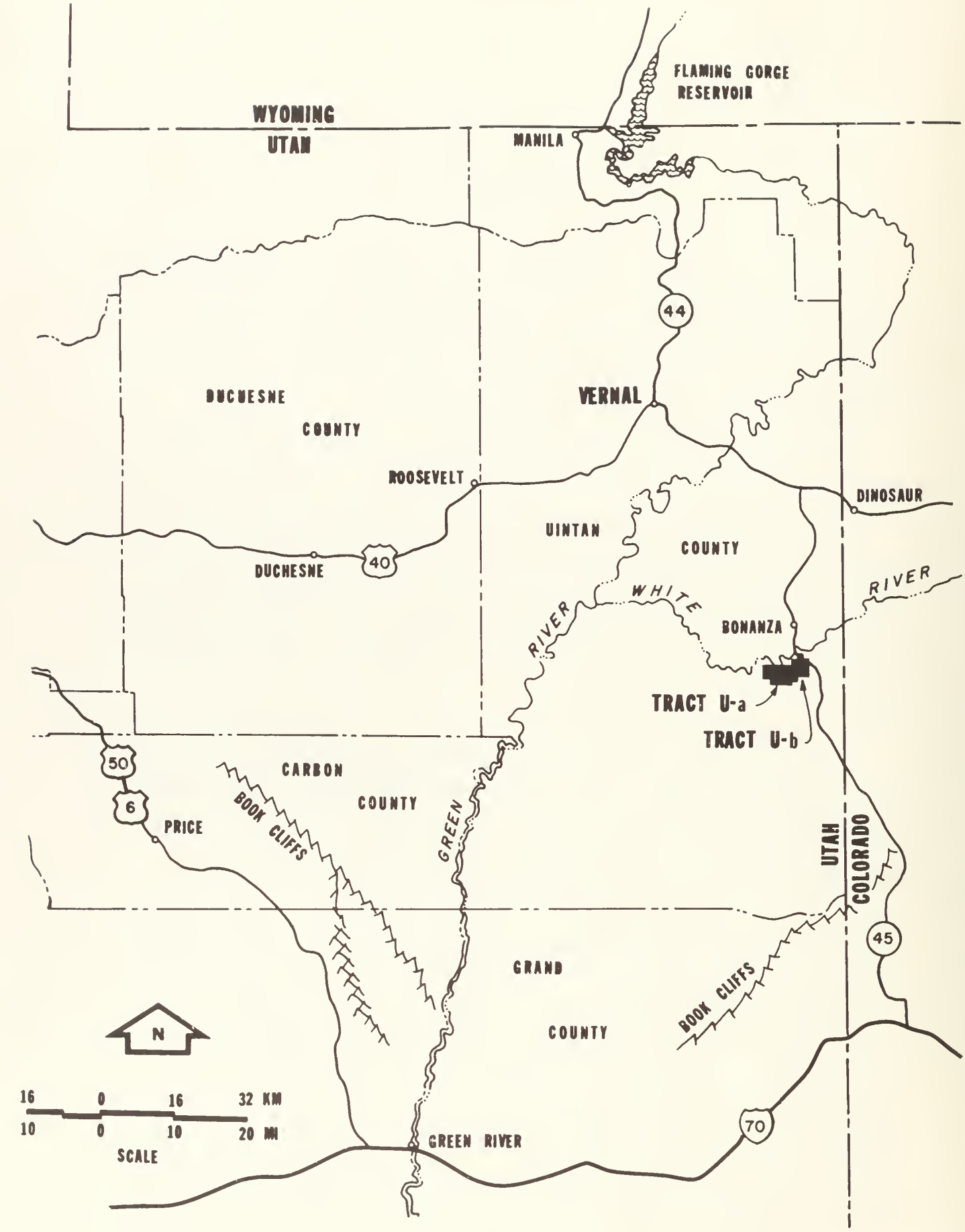
INTRODUCTION

The White River Shale Project (WRSP) was formed in 1974 to carry out the joint development of the two Federal Prototype Oil Shale Leasing Program Tracts in Utah. These tracts are called Ua and Ub. Figure 2.0-1 shows the location of these two 5,120 acre tracts.

Ua and Ub are located about fifty road miles southeast of Vernal, Utah. The White River flows just to the north of the properties.

WRSP is responsible to Phillips Petroleum Company, Sohio Shale Oil Company, and Sunoco Energy Development Company (Sunedco) for making and implementing plans for the development of the oil shale resource of Tracts Ua and Ub. Sunedco and Phillips hold the lease to Ua. Sohio holds the Ub lease.

Three significant tasks have been completed by WRSP since work under the leases began in 1974. First, the Detailed Development Plan required by the leases was submitted to the U. S. Geological Survey -- Area Oil Shale Supervisor (AOSS) in June of 1976. This plan describes the schedule, activities, and expected results associated with the planning, construction, and operation of a commercial shale oil production facility on Tracts Ua and Ub. Second, the required two year environmental monitoring and data collection program was completed in January 1977. The final report on this work was published in October of 1977. Third, to develop a technology for revegetating disturbed sites and processed shale disposal areas, a study was conducted covering the period November, 1974 through December, 1978 and a final report issued in June, 1979.



PROJECT LOCATION MAP
TRACTS U-a & U-b

FIGURE 2.0-1

Operations under the Ua and Ub leases were initially suspended by the Department of Interior for one year starting November 1, 1976. This action postponed the implementation of the program described in the Detailed Development Plan. The lease terms were suspended because environmental monitoring work had shown the presence of ozone and non-methane hydrocarbon gases in the air around the Ua and Ub tracts at levels which exceeded the National Ambient Air Quality Standards. In January, 1979 the standard for ozone was revised which allowed higher ambient levels of ozone to be acceptable. Since this change, violations of the ozone standard have not occurred on Ua/Ub tracts.

A second suspension of lease terms became effective May 31, 1977, which preceded expiration of the Department of Interior's first suspension period. This second suspension was granted by the Utah Federal District Court in favor of WRSP against the Department of Interior. The basis for this injunction involved several questions regarding the current and eventual validity of the Federal leases held by the WRSP companies. These questions arose following 1977 court decisions involving unpatended mining claims and litigation concerning another company's filing for a Utah state lease on the area covered by the Federal leases to Ua and Ub.

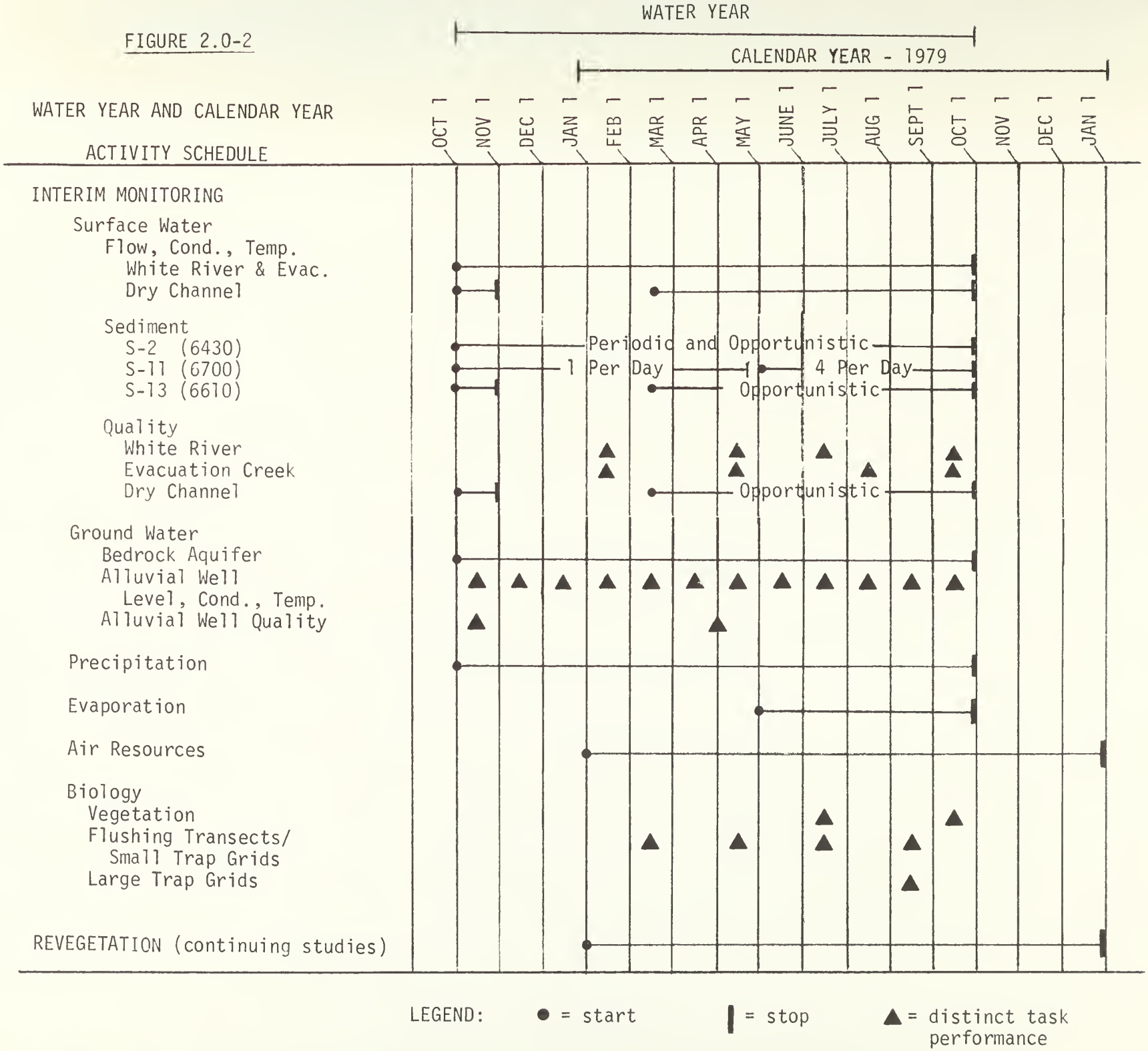
The court order suspending the terms, obligations, and conditions of Ua and Ub Federal lease terms was in effect during 1979.

WRSP, however, has continued to collect data concerning air, water, and biological resources around Ua/Ub. The basic reasons for this decision were a desire to confirm some observations made during the baseline study period, evaluate environmental trends apparent through multi-year study, track ambient ozone and non-methane hydrocarbon levels over an extended period, evaluate more refined biological resources

monitoring techniques, and to complete a revegetation research program. The scope of activities carried out during 1979 are shown in Figure 2.0-2.

The purpose of this "Annual Report -- Environmental Programs" is to report on the results of activities related to WRSP's environmental monitoring, data collection, and research efforts associated with Tracts Ua and Ub during 1979.

FIGURE 2.0-2


WATER YEAR
CALENDAR YEAR - 1979
WATER YEAR AND CALENDAR YEAR
ACTIVITY SCHEDULE
OCT 1
NOV 1
DEC 1
JAN 1
FEB 1
MAR 1
APR 1
MAY 1
JUNE 1
JULY 1
AUG 1
SEPT 1
OCT 1
NOV 1
DEC 1
JAN 1
INTERIM MONITORING
Surface Water
Flow, Cond., Temp.
White River & Evac.
Dry Channel
Sediment
S-2 (6430)
S-11 (6700)
S-13 (6610)
Periodic and Opportunistic
1 Per Day
4 Per Day
Opportunistic
Quality
White River
Evacuation Creek
Dry Channel
Opportunistic
Ground Water
Bedrock Aquifer
Alluvial Well
Level, Cond., Temp.
Alluvial Well Quality
Precipitation
Evaporation
Air Resources
Biology
Vegetation
Flushing Transects/
Small Trap Grids
Large Trap Grids
REVEGETATION (continuing studies)
LEGEND:
● = start
▌= stop
▲= distinct task performance

Section 3.0

BASELINE ENVIRONMENTAL MONITORING PROGRAM

The purpose of the Final Environmental Baseline Report was to present the results of two years of environmental baseline monitoring and data collection as required by the lease terms of the Federal Prototype Oil Shale Leases Ua and Ub. Data collection was completed on January 15, 1977, and the final report published in October, 1977.

The program's purpose was to compile data to determine the environmental conditions existing on the tracts prior to any development operations under the leases. It provides a reference point for evaluating both natural and anthropogenic changes.

The baseline period was generally the years 1975 and 1976. The two baseline "water" years, however, were October 1, 1974 through September 30, 1976.

Section 4.0

ENVIRONMENTAL MONITORING PROGRAM

The purpose of this section is to discuss the work carried out during 1979 regarding the water, air, and biological resources of Tracts Ua and Ub. This work is a continuation of the environmental monitoring program that has operated without interruption since 1974.

The majority of the background environmental monitoring data necessary to satisfy the requirements of the lease, acquire permits, and provide a base for evaluating the effects of oil shale development was completed during the two-year Environmental Baseline Monitoring and Data Collection Program. Consequently, the environmental monitoring program since January 1977 has been continued for three primary reasons: (1) to maintain the applicability of the baseline results to future periods of time, (2) to track ambient ozone and non-methane hydrocarbons concentration levels, and (3) to evaluate techniques for separating natural fluctuations in the parameters that affect the ecosystem from those induced by human activities.

The program carried out since the completion of the Baseline study is called the Interim Monitoring Program. It is anticipated that this interim program will continue during all or part of the time between the completion of the Baseline study period and commencement of the monitoring activities that will be conducted during oil shale development work on Ua and Ub.

The remainder of this section discusses work conducted during the period October 1, 1978 - September 30, 1979 for water resources, and during January 1, 1979 - December 31, 1979 for air and biological resources.

4.1 WATER RESOURCES

The two year water resources Environmental Baseline Monitoring Program was completed in total in January 1977. An Interim Monitoring Program was implemented after completion of the Baseline Program. This section of the Progress Report presents and discusses the water resources monitoring work performed during the period October 1, 1978 through September 30, 1979.

The United States Geological Survey (USGS) has been conducting a water resources data collection program in the Southeastern Uintah Basin. During the 1979 water year, the USGS efforts involved the collection of streamflow and water quality data in the immediate vicinity of Tracts Ua/Ub. The WRSP surface water monitoring program was designed to be used in conjunction with pertinent portions of the USGS program. The two data collection programs combined monitored streamflow, suspended sediment, and water quality at locations on the White River, Evacuation Creek, and at the mouth of Southam Canyon. Also, streamflow was monitored at the mouths of Hell's Hole Canyon and Asphalt Wash.

The Bird's Nest and Upper aquifers were continuously monitored for water level fluctuations. Additional water level measurements of ground water were taken for area correlation.

Alluvial aquifers were monitored for water levels and water quality at locations downstream of the tracts on the White River, near the mouth of Evacuation Creek, and at the mouth of Southam Canyon.

Precipitation and evaporation were monitored at the proposed plant site, in Southam Canyon, and in the surrounding area.

Figure 4.1-1 shows the locations of sites for the four types of monitoring being conducted -- surface water, bedrock aquifer water, alluvial aquifer water, and precipitation/evaporation. All supporting data are shown in the figures and tables of the text and in the field data appendix. All USGS data in this report are preliminary and subject to revision.

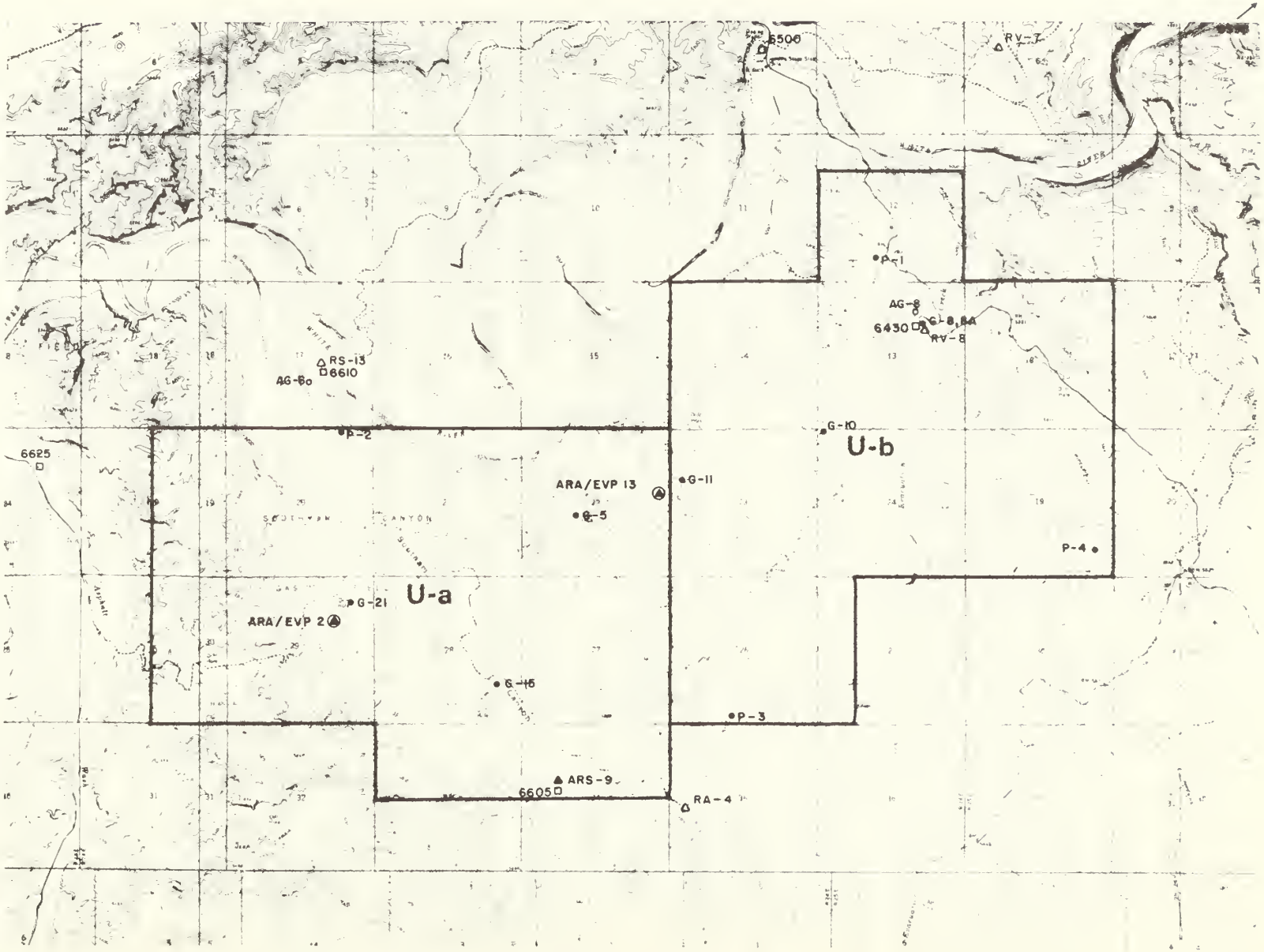
VTN Consolidated, Inc. is under contract to WRSP to conduct the water resources monitoring program.

4.1.1 Surface Water

In the past, more than one system of nomenclature has been used for surface water stations. This report will use only the USGS system of nomenclature for station numbers and names. A comparison of nomenclature for surface water stations is shown in Table 4.1-1. Also, only the last four digits of the USGS station numbers will be used in the text. The surface water monitoring program comprised work efforts of both the USGS Water Resources Division and WRSP. The division of responsibilities is shown in Table 4.1-2. Based on announcements by the the USGS just prior to the 1979 water year, it was anticipated that the USGS would not collect any data at stations 6405, 6500 and 6625 during the 1979 water year. Also, WRSP felt, at that time, that these data were not critical to the monitoring program. Therefore, these three stations are not shown in Table 4.1-2. It turned out that some data were collected at these stations, so it is also presented in this report.

The operation of Station 6430 was taken over from the USGS on December 7, 1978.

WATER RESOURCES MONITORING SITES



RS-11

6700 AG-3

LEGEND

- □ SURFACE WATER
- ● DEEP AQUIFER WATER
- ○ ALLUVIAL AQUIFER WATER
- ▲ PRECIPITATION (AUTOMATIC)
- △ PRECIPITATION (STORAGE)
- ◉ PRECIPITATION (AUTO.)/EVAPORATION PAN

UTAH

N

1 0 1

SCALE IN MILES

FIGURE 4.1-1

TABLE 4.1-1

COMPARISON OF NOMENCLATURE FOR
SURFACE WATER STATIONS

Designation 1 (WRSP)	Designation 2 (USGS)	Name (USGS)
	09306395	White River near Colorado-Utah State Line, Utah
S-5	09306405	Hell's Hole Canyon Creek at mouth, near Watson, Utah
S-2	09306430	Evacuation Creek near Watson, Utah
S-3	09306500	White River near Watson, Utah
S-9	09306605	Southam Canyon Wash near Watson, Utah
S-13	09306610	Southam Canyon Wash at Mouth, near Watson, Utah
S-12	09306625	Asphalt Wash near mouth, near Watson, Utah
S-11	09306700	White River below Asphalt Wash, near Watson, Utah

TABLE 4.1-2

RESPONSIBILITY FOR SURFACE WATER MONITORING

Station	Monitoring Activity	Responsibility
	Streamflow	
6430, 6700	Continuous monitoring	WRSP
6610:	Continuous monitoring during snowmelt and thunderstorm seasons (approximately February through October)	WRSP
6395	Continuous monitoring	USGS
	Suspended Sediment	
6700	Continuous monitoring (4 samples daily during peak flow and thunderstorm season, 1 sample daily during winter baseflow)	WRSP
6430	Periodic and opportunistic samples	WRSP
6610	Opportunistic samples	WRSP
6395	Continuous monitoring	USGS
	Water Quality	
6700	Continuous monitoring of temperature and specific conductance	WRSP
6430	Quarterly samples in January, April, July and September; continuous monitoring of temperature and specific conductance	WRSP
6610	Opportunistic samples; continuous monitoring of temperature and specific conductance during snowmelt and thunderstorm seasons	WRSP
6395	Quarterly samples in January, April, July, and September; continuous monitoring of temperature and specific conductance	USGS

4.1.1.1 Objective. The objective of the surface water monitoring program is to ensure the applicability of the two-year Baseline data to future monitoring periods.

4.1.1.2 Methods. Data collection efforts during the reporting period were concerned with streamflow, suspended sediment, and water quality.

Streamflow was measured continuously by the WRSP on the White River downstream from the tracts (station 6700) and on Evacuation Creek (station 6430). The gauging station visitation and maintenance schedule was sufficient to provide, as near as practical, continuous streamflow measurement throughout the year. Discharge measurements were made with a current meter as frequently as called for by good hydrological practices, but no less frequently than once per month. The digital recorder tapes were removed and processed monthly.

Streamflow was also measured by WRSP in lower Southam Canyon (station 6610). This station was in operation during the snowmelt and thunderstorm seasons from October 1, 1978 through November 2, 1978 and March 6, 1979 through September 30, 1979. The station was visited during the period of operation at least once each month. The digital recorder tapes were removed and processed once a month.

Streamflow was monitored continuously by the USGS at station 6395 on the White River below the Colorado State line and at station 6500 on the White River near Watson. Stations 6625 near the mouth of the Asphalt Wash and 6405 at the mouth of Hell's Hole Canyon were in operation throughout the year.

Suspended sediment was monitored by WRSP at station 6700. The automatic suspended sediment sampler at this site was to be operated continuously throughout the year according to the Work Plan. This was not accomplished due to several factors. These included: freezing of the intake line during the winter, mechanical breakdowns of the sampler, and damage to the intake line during high flow. While the automatic sampler was out of operation, manual suspended sediment samples were collected at least every two weeks, except when the station could not be reached due to snow and when the ice cover on the river was breaking up. While the automatic sampler was in operation, manual suspended sediment samples were collected at intervals necessary to ensure calibration of the automatic sampler (at least every two weeks).

Manual suspended sediment samples were collected by WRSP at stations 6430 and 6610. Single-stage samplers were also maintained at both stations to enhance the chances for data collection during high flow events. Suspended sediment samples from stations 6430, 6610 and 6700 were analyzed by WRSP.

The USGS maintained an automatic suspended sediment sampler at station 6395 and also collected manual suspended sediment samples.

Water quality samples were collected by WRSP at station 6430 in February, April, July and September. The USGS collected an additional sample at this station in March. Water quality samples were collected at station 6610 by WRSP and by the USGS in March (one each). The USGS collected water quality samples at station 6395 in January, April,

June and September; and at station 6500 in October, November, February, March, April, May and June. Additional samples were collected by the USGS in March at stations 6405 and 6625. All water quality samples were analyzed by the USGS Central Laboratory in Denver, Colorado.

Temperature and specific conductance were measured continuously by WRSP at stations 6430 and 6700 throughout the year, and at station 6610 during October 1-November 2 and March 6-September 30. Probes were checked and calibrated regularly and the digital recorder tapes were removed and processed monthly. The USGS measured these parameters continuously throughout the year at stations 6395 and 6500.

4.1.1.3 Data Summary

Streamflow: White River

The 1979 streamflow hydrographs for stations 6395, 6500 and 6700 on the White River are shown in Figures 4.1-2 through 4.1-4. Baseflow occurred from October through mid-March and resumed in late July. Runoff from snowmelt in the lower basin began in mid-March and lasted until mid-April. Runoff from snowmelt in the upper basin began in mid-April and lasted until late July.

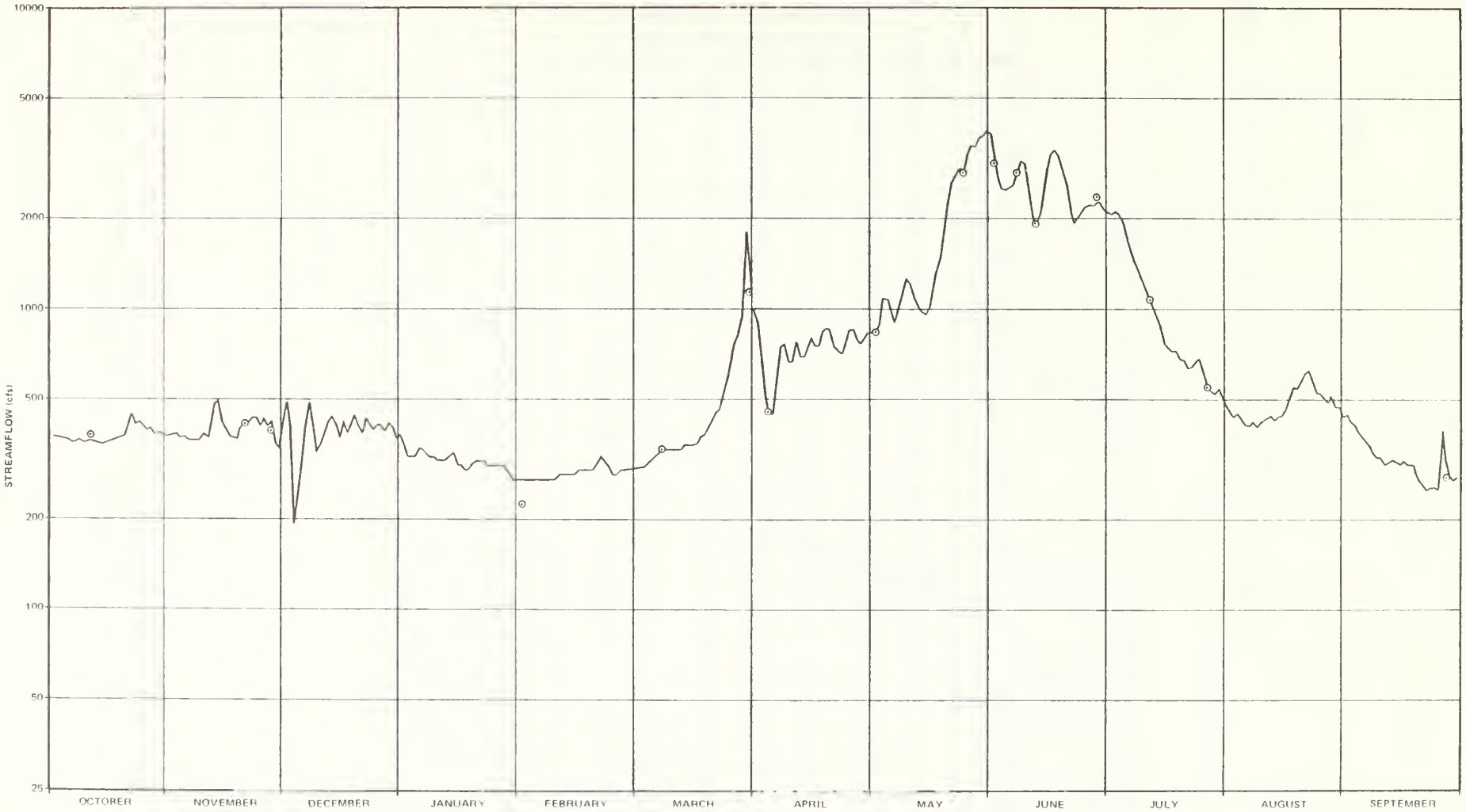
The highest value of mean daily streamflow for these stations during the year was 120 m^3/sec (4,230 cfs) at station 6395 on May 30. The lowest value of mean daily streamflow during the year for these three stations was 4.8 m^3/sec (170 cfs) at station 6395 on December 3. This minimum value was caused by ice formation in the river. The maximum instantaneous streamflow during the year was 127 m^3/sec (4,470 cfs) at station 6395 on May 30. The total annual

LEGEND

⊙ INSTANTANEOUS DISCHARGE MEASUREMENT

WHITE RIVER NEAR COLORADO STATE LINE, UTAH (STA. NO. 09306395)
MEAN DAILY STREAMFLOW
OCTOBER 1978 – SEPTEMBER 1979

FIGURE 4 1-2

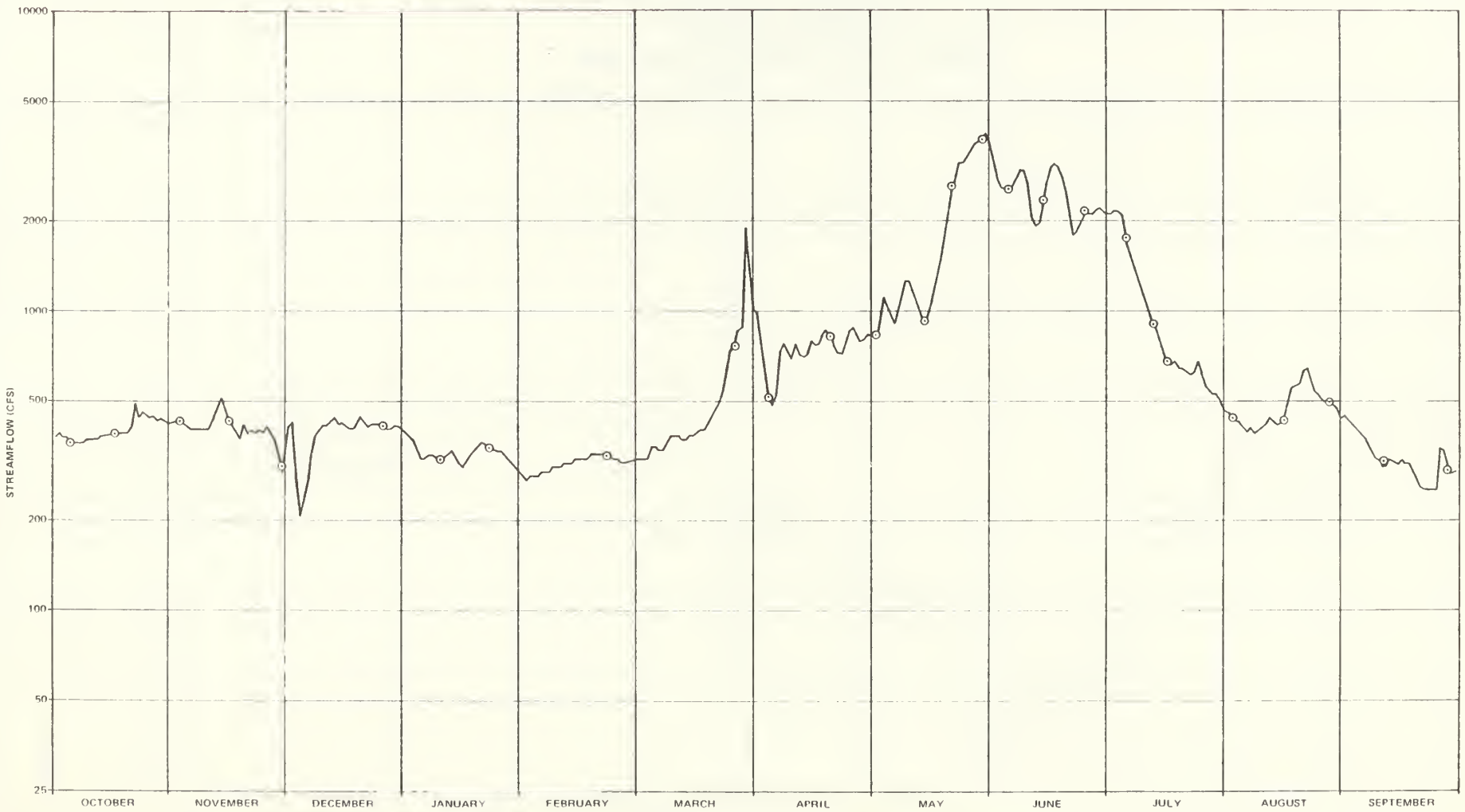


LEGEND

⊙ INSTANTANEOUS DISCHARGE MEASUREMENT

WHITE RIVER NEAR WATSON, UTAH (STA. NO. 09306500)
MEAN DAILY STREAMFLOW
OCTOBER 1978 – SEPTEMBER 1979

FIGURE 4.1-3



LEGEND

⊙ INSTANTANEOUS DISCHARGE MEASUREMENT

WHITE RIVER BELOW ASPHALT WASH, NEAR WATSON, UTAH (STA. 09306700)
MEAN DAILY STREAMFLOW
OCTOBER 1978 – SEPTEMBER 1979

FIGURE 4.1-4

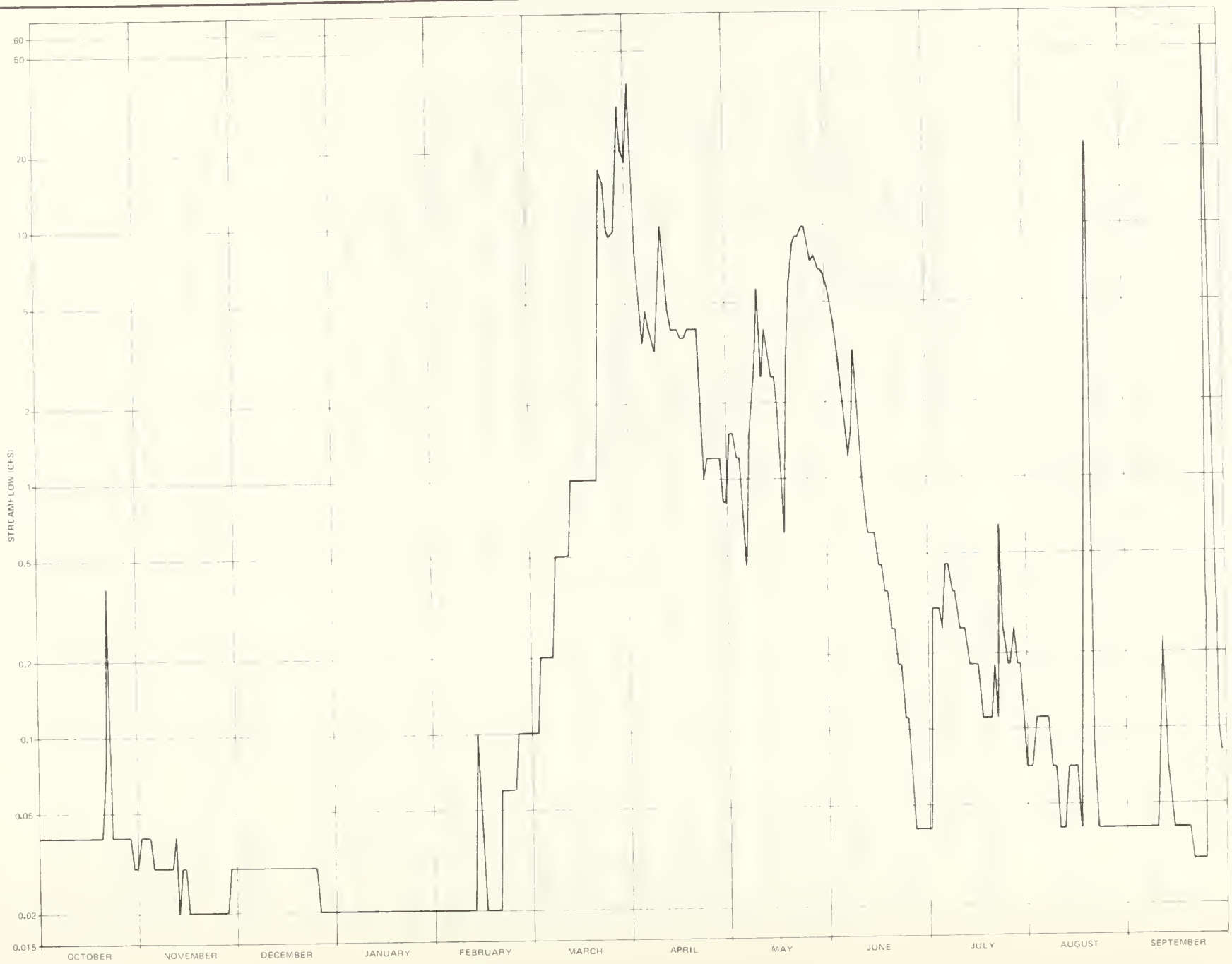
runoff varied from 68,320 hectare-meters (553,900 acre-feet) at station 6395 to 68,880 hectare-meters (558,400 acre-feet) at station 6700. This amounts to an increase in total annual runoff of 0.8% from the upstream station to the downstream station.

Streamflow: Evacuation Creek

The 1979 streamflow hydrograph for station 6430 near the mouth of Evacuation Creek is shown in Figure 4.1-5. Snowmelt runoff began in late February and lasted until mid-June. There were two days of high flow on August 18 and 19 due to runoff during a sustained rainy period. On September 26 here was a flash flood due to an intense, isolated thunderstorm in the drainage. The peak discharge during this event was 56.1 m^3/sec (1,980 cfs), which was also the maximum instantaneous streamflow during the year. This peak discharge value was determined by an indirect measurement using a four-section slope-area method. During most of the year, the streamflow of Evacuation Creek was sustained by baseflow, rather than snowmelt or thunderstorm runoff. Mean daily streamflow at this station during the year ranged from a minimum of 0.001 m^3/sec (0.02 cfs) on many days to a maximum of 1.7 m^3/sec (59 cfs) on September 26. Total annual runoff was 144 hectare-meters (1,170 acre-feet).

Streamflow: Dry Washes

The mean daily streamflow values during 1979 for stations 6405, 6610 and 6625 are shown in Tables 4.1-3, 4.1-4 and 4.1-5. The maximum mean daily values of streamflow during the year were 0.23 m^3/sec (8.0 cfs) for station 6405 in Hell's Hole Canyon, 0.13 m^3/sec (4.7 cfs)



EVACUATION CREEK NEAR WATSON, UTAH (STA. NO. 09306430)
MEAN DAILY STREAMFLOW
OCTOBER 1978 – SEPTEMBER 1979

FIGURE 4.1-5

TABLE 4.1-3

HELL'S HOLE CANYON AT MOUTH, NEAR WATSON, UTAH (STA. NO. 09306405)
MEAN DAILY DISCHARGE (CFS)
OCTOBER 1978 - SEPTEMBER 1979

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1						.00	4.0	.01			.00	.00
2						.00	3.5	.00			.00	.00
3						.00	1.4	.00			.00	.00
4						.00	.04	.00			.00	.00
5						.00	.01	.00			.00	.00
6						.00	.03	.00			.00	.00
7						.00	.03	.00			.00	.00
8						.00	.04	.00			.00	.00
9						.00	.05	.02			.00	.00
10						.00	.07	.00			.00	.00
11						.00	.07	.00			.00	.00
12						.00	2.5	.00			.00	.00
13						.00	2.0	.00			.00	.00
14						.00	.76	.00			.00	.00
15						.00	.05	.00			.00	.00
16						.00	.03	.00			.00	.00
17						.00	.02	.00			.00	.00
18						.00	.02	.00			.00	.00
19						.00	.05	.00			.50	.00
20						.00	.07	.00			.00	.00
21						.00	.07	.00			.00	.00
22						.00	.05	.00			.00	.00
23						.00	.04	.00			.00	.00
24						.00	.04	.00			.00	.00
25						.00	.03	.00			.00	.00
26						.00	.02	.00			.00	8.0
27						.00	.00	.00			.00	.00
28						.02	.00	.00			.00	.00
29						.00	.00	.00			.00	.00
30						.73	.00	.00			.00	.00
31						3.0	--	.00			.00	--
TOTAL	.00	.00	.00	.00	.00	3.75	14.99	.03	.00	.00	.50	8.0
MEAN	.000	.000	.000	.000	.000	.12	.50	.001	.000	.000	.016	.27
MAX	.00	.00	.00	.00	.00	3.0	4.0	.02	.00	.00	.50	8.0
MIN	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
AC-FT	.00	.00	.00	.00	.00	7.4	30	.06	.00	.00	1.0	16

WATER YEAR 1979 TOTAL 27.27 MEAN .075 MAX 8.0 MIN .00 ACRE-FEET 54

TABLE 4.1-4

SOUTHAM CANYON WASH AT MOUTH, NEAR WATSON, UTAH (STA. NO. 09306610)
MEAN DAILY DISCHARGE (CFS)
OCTOBER 1978 - SEPTEMBER 1979

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1						0	.002					0
2						0	0					0
3						0	0					0
4						0	0					0
5						0	0					0
6						0	0					0
7						0	0					0
8						0	0					0
9						0	0					0
10						0	0					0
11						0	0					0
12						0	0					0
13						0	0					0
14						0	0					0
15						0	0					0
16						0	0					0
17						0	0					0
18						0	0					0
19						0	0					0
20						0	0					0
21						0	0					0
22						0	0					0
23						0	0					0
24						0	0					0
25						0	0					0
26						0	0					4.7
27						0	0					0
28						.023	0					0
29						.245	0					0
30						0	0					0
31						.045						
TOTAL	0	0	0	0	0	.713	.002	0	0	0	0	4.7
MEAN	0	0	0	0	0	.023	.00007	0	0	0	0	0.157
MAX	0	0	0	0	0	.245	.002	0	0	0	0	4.7
MIN	0	0	0	0	0	0	0	0	0	0	0	0
AC-FT	0	0	0	0	0	1.4	.004	0	0	0	0	9.3

WATER YEAR 1979 TOTAL 5.415 MEAN .015 MAX 4.7 MIN 0 ACRE-FEET 11

TABLE 4.1-5

ASPHALT WASH NEAR MOUTH, NEAR WATSON, UTAH (STA. NO. 09306625)
MEAN DAILY DISCHARGE (CFS)
OCTOBER 1978 - SEPTEMBER 1979

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1						.00	6.0					.00
2						.00	3.0					.00
3						.00	2.0					.00
4						.00	1.0					.00
5						.00	.50					.00
6						.00	.00					.00
7						.00	.00					.00
8						.00	.00					.00
9						.00	.00					.00
10						.00	.00					.00
11						.00	.00					.00
12						.00	.00					.00
13						.00	.00					.00
14						.00	.00					.00
15						.00	.00					.00
16						.00	.00					.00
17						.00	.00					.00
18						.00	.00					.00
19						.00	.00					.00
20						.00	.00					.00
21						.00	.00					.00
22						.03	.00					.00
23						.00	.00					.00
24						.00	.00					.00
25						.00	.00					.00
26						.00	.00					2.6
27						.00	.00					.00
28						16	.00					.00
29						15	.00					.00
30						12	.00					.00
31						9.7	--					--
TOTAL	.00	.00	.00	.00	.00	52.73	12.50	.00	.00	.00	.00	2.60
MEAN	.00	.000	.000	.000	.000	1.70	.42	.000	.000	.000	.000	.087
MAX	.00	.00	.00	.00	.00	16	6.0	.00	.00	.00	.00	2.6
MIN	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
AC-FT	.00	.00	.00	.00	.00	105	25	.00	.00	.00	.00	5.2

WATER YEAR 1979 TOTAL 67.83 MEAN .19 MAX 16 MIN .00 ACRE-FEET 135

for station 6610 in Southam Canyon, and 0.45 m^3/sec (16 cfs) for station 6625 in Asphalt Wash. These maximum values occurred on September 26 due to thunderstorm runoff for stations 6405 and 6610, and on March 28 due to snowmelt runoff for station 6625. The minimum daily streamflow for all three stations was zero on most of the days during the year.

The peak discharge for the flow event at station 6610 on September 26 was 11.1 m^3/sec (392 cfs), which was also the maximum instantaneous streamflow during the year. This value was determined by an indirect measurement using a four-section slope-area method. An indirect measurement of the same flow event at station 6605 in Southam Canyon at the upstream edge of Tract Ua determined that the peak discharge was also 11.1 m^3/sec (392 cfs). This station has not been operated during the Interim period. A comparison of these two peak discharges leads to the conclusion that most of the runoff making up this flow event was contributed by the portion of the Southam Canyon drainage which is upstream of Tract Ua. This conclusion coincides with the measured precipitation values for that storm, which are presented in section 4.1.4.3. The maximum instantaneous streamflow during the year at stations 6405 and 6625 was 13.2 m^3/sec (467 cfs) and 2.86 m^3/sec (101 cfs). Both of these events occurred on September 26.

The total 1979 annual runoff volumes for stations 6405, 6610 and 6625 were 6.7 hectare-meters (54 acre-feet), 1.4 hectare-meters (11 acre-feet), and 16.7 hectare-meters (135 acre-feet).

Water Quality: White River

The 1979 water quality data for stations 6395 and 6500 are shown in Table 4.1-6. The source of streamflow is shown under the date for each sample (see the streamflow discussion for more details on sources of streamflow). The samples collected on April 26 occurred during the transition from lower basin runoff to upper basin runoff. The parameters have been grouped according to general categories.

No water quality samples were collected at station 6700 during the 1979 water year, because the previous four years of record had indicated that there were no significant differences in water quality between the stations on the White River.

General Characteristics: The variation in time of two of the general characteristics (dissolved solids and pH) is shown in Figure 4.1-6. The concentration of dissolved solids generally followed an inverse relationship to the magnitude of streamflow, with the exception that during lower basin runoff, streamflow and dissolved solids levels were both greater than during baseflow. The range of concentrations during the year varied from 225 mg/l during upper basin runoff to 692 mg/l during lower basin runoff.

The values of pH were relatively stable during the year ranging from 7.4 to 8.5 (see Figure 4.1-6). The pH values shown for station 6700 in this figure are additional field values not given in Table 4.1-6. Alkalinity generally followed an inverse relationship to streamflow, and did not show a rise during lower basin runoff. In contrast to this, total and noncarbonate hardness followed the same trend as dissolved solids.

TABLE 4.1-6

SUMMARY OF WHITE RIVER WATER QUALITY
October 1978-September 1979

Station		6500	6500	6395	6500	6500	6395	6500	6500	6395	6395	6500	6395
Date		Oct 11	Nov 28	Jan 16	Feb 1	Mar 30	Apr 26	Apr 26	May 24	June 5	June 6	June 6	Sept 18
Source of Flow		BF	BF	BF	BF	LBR	LBR+UBR	LBR+UBR	UBR	UBR	UBR	UBR	BF
GENERAL CHARACTERISTICS													
Total Alkalinity as $CaCO_3$	(mg/l)	150	170	160	160	150	160	160	120	120	110	110	170
Dissolved Solids, Residue at 180°C	(mg/l)	--	--	--	--	--	--	--	--	242	--	--	511
Dissolved Solids, calc. sum	(mg/l)	455	447*	436	543	692	421	435	258	234	225	226	515
Total Hardness as $CaCo_3$	(mg/l)	260	260	240	290	320	240	240	160	160	150	160	270
Noncarbonate Hardness as $CaCO_3$	(mg/l)	110	--	85	130	170	83	79	40	41	41	48	98
pH	(units)	8.4	8.3	7.7	7.4	8.1	7.7	8.0	7.2	8.2	8.3	8.3	8.4
Specific Conductance at 25°C	(umhos/cm)	710	670	660	730	950	680	800	406	370	370	360	770
Streamflow, Instantaneous	(cfs)	385	391	287	222	1120	871	798	2800	2900	2950	2580	320
Temperature	(°C)	15.0	0.5	0.0	0.0	3.5	13.0	15.0	14.0	17.0	16.0	18.0	18.5
MAJOR CATIONS													
Calcium, dissolved	(mg/l)	69	66	65	76	85	56	56	39	41	39	40	66
Magnesium, dissolved	(mg/l)	22	22	20	24	26	25	24	15	14	13	14	25
Potassium, dissolved	(mg/l)	1.8	1.7	1.6	1.7	3.6	2.2	2.3	2.1	1.7	1.5	1.4	2.2
Sodium, dissolved	(mg/l)	51	55	49	62	110	52	52	28	21	21	21	68
Sodium Adsorption Ratio		1.4	1.5	1.4	1.6	2.7	1.5	1.5	1.0	0.7	0.7	0.7	1.7
Percent Sodium		30	32	30	32	43	32	32	27	22	23	31	47
Strontium, dissolved	(ug/l)	--	--	--	870	--	--	--	470	370	380	360	830
MAJOR ANIONS													
Bicarbonate	(mg/l)	180	207*	195*	195*	183*	195*	195*	146*	146*	134*	134*	204*
Carbonate	(mg/l)	3	0*	0*	0*	0*	0*	0*	0*	0*	0*	0*	3*
Chloride, dissolved	(mg/l)	35	37	37	44	35	24	27	7.5	7.7	7.9	7.8	39
Sulfate, dissolved	(mg/l)	170	150	150	220	330	150	160	82	66	66	65	200
Sulfide as S, total	(mg/l)	--	--	--	--	--	--	--	--	--	--	--	0.0
Fluoride, dissolved	(mg/l)	0.3	0.2	0.2	0.2	0.3	0.2	0.3	0.2	0.3	0.3	0.2	0.3
Bromide, dissolved	(mg/l)	--	--	--	--	--	--	--	--	0.0	--	--	0.1

TABLE 4.1-6 (cont.)

Station Date Source of Flow		6500 Oct 11 BF	6500 Nov 28 BF	6395 Jan 16 BF	6500 Feb 1 BF	6500 Mar 30 LBR	6395 Apr 26 LBR+UBR	6500 Apr 26 LBR+UBR	6500 May 24 UBR	6395 June 5 UBR	6395 June 6 UBR	6500 June 6 UBR	6395 Sept 18 BF
BIOCHEMICAL CONSTITUENTS													
Dissolved Oxygen	(mg/l)	9.4	11.6	8.4	8.1	9.0	8.0	7.9	7.4	--	--	--	--
Chemical Oxygen Demand	(mg/l)	--	--	--	--	--	--	--	--	--	--	--	16
Organic Carbon, dissolved	(mg/l)	--	--	--	--	--	--	--	--	--	--	--	4.2
Organic Carbon, susp. total	(mg/l)	--	--	--	--	--	--	--	--	--	--	--	0.5
Organic Carbon, total	(mg/l)	--	--	--	--	--	--	--	--	--	--	--	3.2
MACRONUTRIENTS													
Ammonia as N, dissolved	(mg/l)	--	--	--	--	--	--	--	--	--	--	--	0.00
Ammonia as N, total	(mg/l)	--	--	--	--	--	--	--	--	--	--	--	0.02
Nitrite plus Nitrate as N, diss.	(mg/l)	0.02	0.03	0.25	0.26	1.2	0.38	0.41	0.38	--	--	--	0.04
Nitrite plus Nitrate as N, total	(mg/l)	--	--	--	--	--	--	--	--	--	--	--	0.03
Organic Nitrogen as N, total	(mg/l)	--	--	--	--	--	--	--	--	--	--	--	0.39
Ammonia plus Organic Nitrogen as N, total	(mg/l)	--	--	--	--	--	--	--	--	--	--	--	0.41
Total Nitrogen as N	(mg/l)	--	--	--	--	--	--	--	--	--	--	--	0.44
Total Phosphorus as P	(mg/l)	--	--	--	--	--	--	--	--	--	--	--	0.01
Ortho-Phosphorus as P, dissolved	(mg/l)	--	0.02	0.00	--	0.02	0.01	0.02	--	--	--	--	--
Ortho-Phosphorus as P, total	(mg/l)	--	--	--	--	--	--	--	--	--	--	--	0.01
MICRONUTRIENTS													
Boron, dissolved	(ug/l)	70	70	60	70	150	70	100	50	40	50	50	60
Copper, dissolved	(ug/l)	--	--	--	--	--	--	--	--	1	--	--	2
Copper, susp. rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	0
Copper, total rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	2
Iron, dissolved	(ug/l)	--	--	10	--	--	30	--	--	20	120	40	0
Iron, susp. rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	350
Iron, total rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	350
Manganese, dissolved	(ug/l)	--	--	5	--	--	2	--	--	10	30	0	10
Manganese, susp. rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	10
Manganese, total rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	20

TABLE 4.1-6 (cont.)

Station Date Source of Flow		6500 Oct 11 BF	6500 Nov 28 BF	6395 Jan 16 BF	6500 Feb 1 BF	6500 Mar 30 LBR	6395 Apr 26 LBR+UBR	6500 Apr 26 LBR+UBR	6500 May 24 UBR	6395 June 5 UBR	6395 June 6 UBR	6500 June 6 UBR	6395 Sept 18 BF
MICRONUTRIENTS (cont.)													
Zinc, dissolved	(ug/l)	--	--	--	--	--	--	--	--	10	--	--	10
Zinc, susp. rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	0
Zinc, total rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	10
Molybdenum, dissolved	(ug/l)	--	--	--	--	--	--	--	--	1	--	--	--
Cobalt, dissolved	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	0
Cobalt, susp. rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	0
Cobalt, total rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	0
Silica as SiO_2, dissolved	(mg/l)	14	13	16	17	6.6	14	15	9.7	10	10	10	12
TRACE METALS													
Aluminum, dissolved	(ug/l)	--	--	--	--	--	--	--	--	20	50	20	10
Aluminum, total rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	230
Barium, dissolved	(ug/l)	--	--	--	--	--	--	--	--	100	--	--	100
Barium, susp. rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	0
Barium, total rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	100
Cadmium, dissolved	(ug/l)	--	--	--	--	--	--	--	--	2	--	--	2
Cadmium, susp. rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	3
Cadmium, total rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	5
Chromium, dissolved	(ug/l)	--	--	--	--	--	--	--	--	0	--	--	0
Chromium, susp. rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	10
Chromium, total rec.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	10

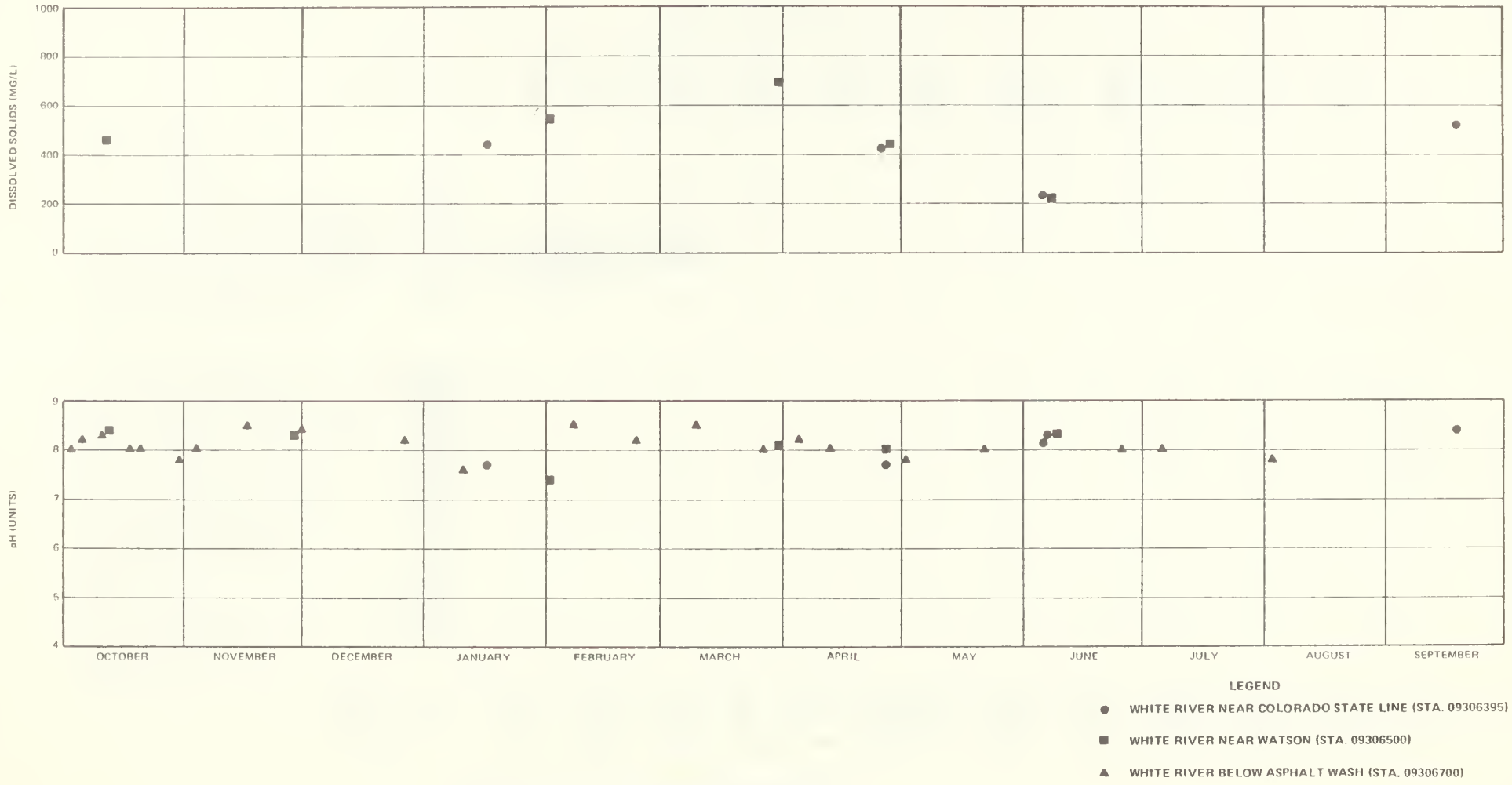
TABLE 4.1-6 (cont.)

Station		6500	6500	6395	6500	6500	6395	6500	6500	6395	6395	6500	6395
Date		Oct 11	Nov 28	Jan 16	Feb 1	Mar 30	Apr 26	Apr 26	May 24	June 5	June 6	June 6	Sept 18
Source of Flow		BF	BF	BF	BF	LBR	LBR+UBR	LBR+UBR	UBR	UBR	UBR	UBR	BF
TRACE NON-METALS													
Arsenic, dissolved	(ug/l)	--	--	--	--	--	--	--	--	1	--	--	1
Arsenic, susp. total	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	0
Arsenic, total	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	1
Phenols	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	1
RADIOACTIVE CONSTITUENTS													
Gross Alpha as U-nat., diss.	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	<8.7
Gross Alpha as U-nat., susp. total	(ug/l)	--	--	--	--	--	--	--	--	--	--	--	<0.4
Gross Beta as Sr-90/Y-90, diss.	(pCi/l)	--	--	--	--	--	--	--	--	--	--	--	<3.2
Gross Beta as Sr-90/Y-90, susp total	(pCi/l)	--	--	--	--	--	--	--	--	--	--	--	0.6
Gross Beta as Cs-137, diss.	(pCi/l)	--	--	--	--	--	--	--	--	--	--	--	<3.1
Gross Beta as Cs-137, susp. total	(pCi/l)	--	--	--	--	--	--	--	--	--	--	--	0.6

*Values calculated by VTN.

Abbreviations: Calc. = calculated
diss. = dissolved
susp. = suspended
rec. = recoverable

BF = Baseflow
LBR = Lower Basin Runoff
UBR = Upper Basin Runoff



VARIATION IN TIME OF GENERAL CHARACTERISTICS

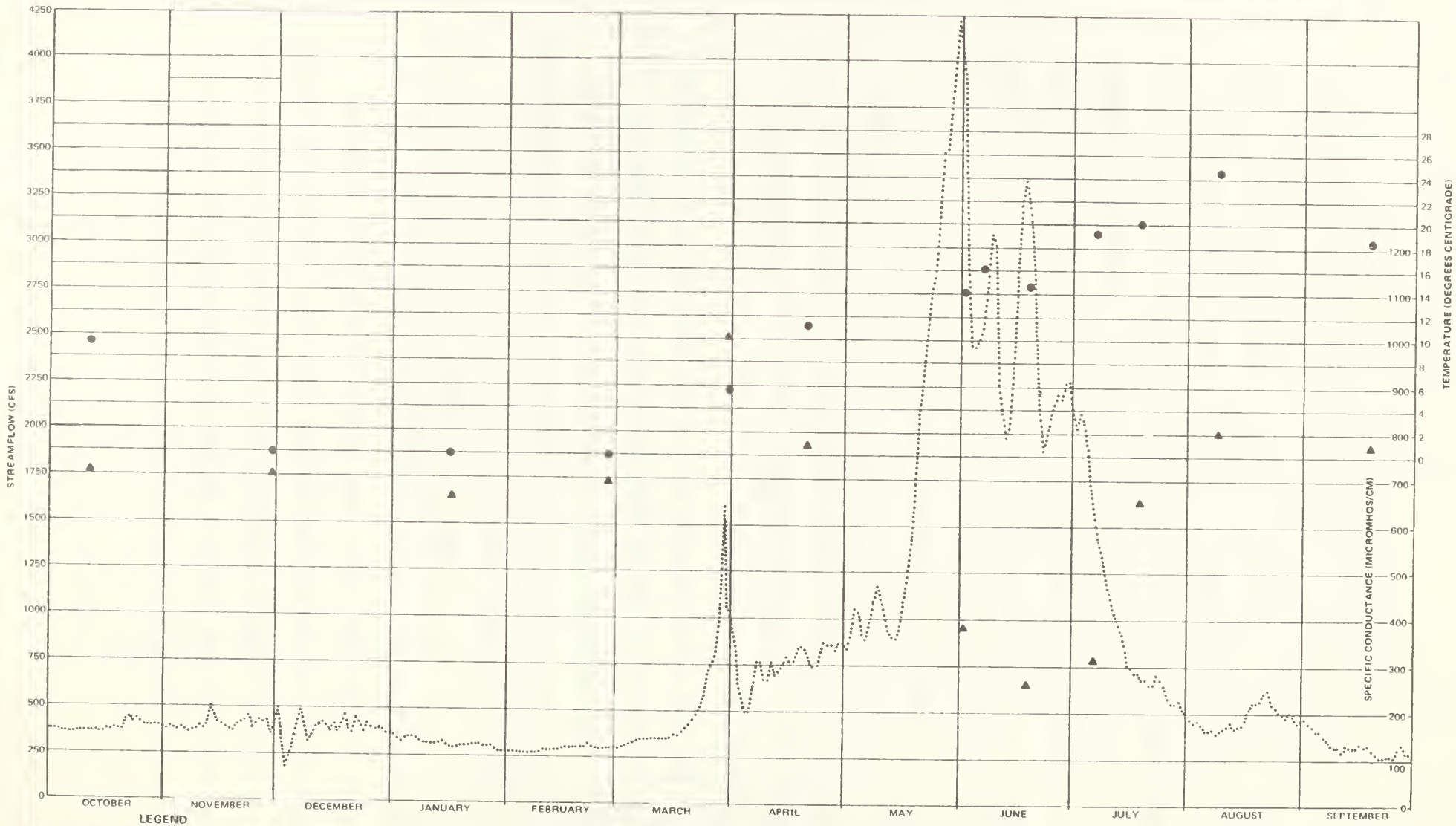
WHITE RIVER NEAR COLORADO STATE LINE TO BELOW ASPHALT WASH

OCTOBER 1978 – SEPTEMBER 1979

FIGURE 4.1-6

The 1979 records of mean daily temperature and specific conductance for stations 6395 and 6500 were not available for this report. However, several instantaneous measurements made during station visits were available for this report. However, several instantaneous measurements made during station visits were available. Figures 4.1-7 and 4.1-8 illustrate the relationship of mean daily streamflow to instantaneous temperature and specific conductance at stations 6395 and 6500. The relationship of mean daily streamflow to mean daily temperature and specific conductance at station 6700 is shown in Figure 4.1-9. As in past years, temperature followed an annual sinusoidal pattern, and ranged from 0.0°C to 25.0°C at station 6700. Specific conductance generally illustrated an inverse relationshp to streamflow, with the exception that during the lower basin runoff period the relationship was direct rather than inverse.

In the 1978 Annual Report, half of the table of daily suspended sediment discharge at station 6395 during the 1978 water year was omitted. These data are shown in Table 4.1-7. The values of instantaneous suspended sediment concentration and discharge at stations 6395 and 6700 during the 1979 water year are shown in Tables 4.1-8 and 4.1-9. These values were obtained from the manually collected samples; the data from the samples collected by the automatic samplers are not available at this time. Also, the records of mean daily suspended sediment discharge are not available at this time. The maximum instantaneous rates of suspended sediment discharge (from the available data) for stations 6395 and 6700 were 38,500 tons/day and 69,500 tons/day, respectively. These occurred during the upper basin runoff period.

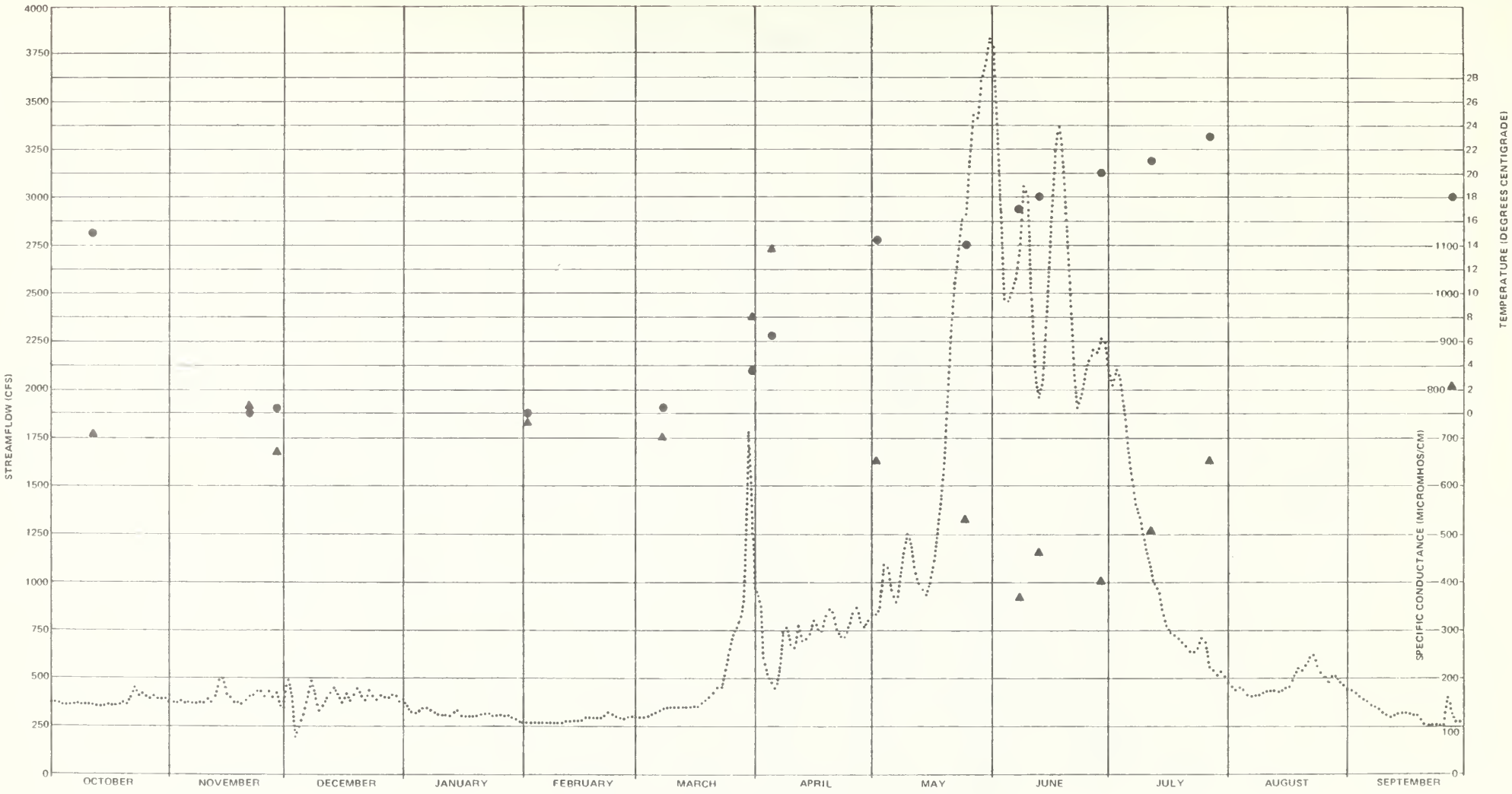


LEGEND

- MEAN DAILY STREAMFLOW
- INSTANTANEOUS TEMPERATURE
- INSTANTANEOUS SPECIFIC CONDUCTANCE

WHITE RIVER NEAR COLORADO STATE LINE, UTAH (STA. 09306395)
MEAN DAILY STREAMFLOW AND INSTANTANEOUS TEMPERATURE AND SPECIFIC CONDUCTANCE
OCTOBER 1978 – SEPTEMBER 1979

FIGURE 4.1-7



LEGEND

····· MEAN DAILY STREAMFLOW

● INSTANTANEOUS TEMPERATURE

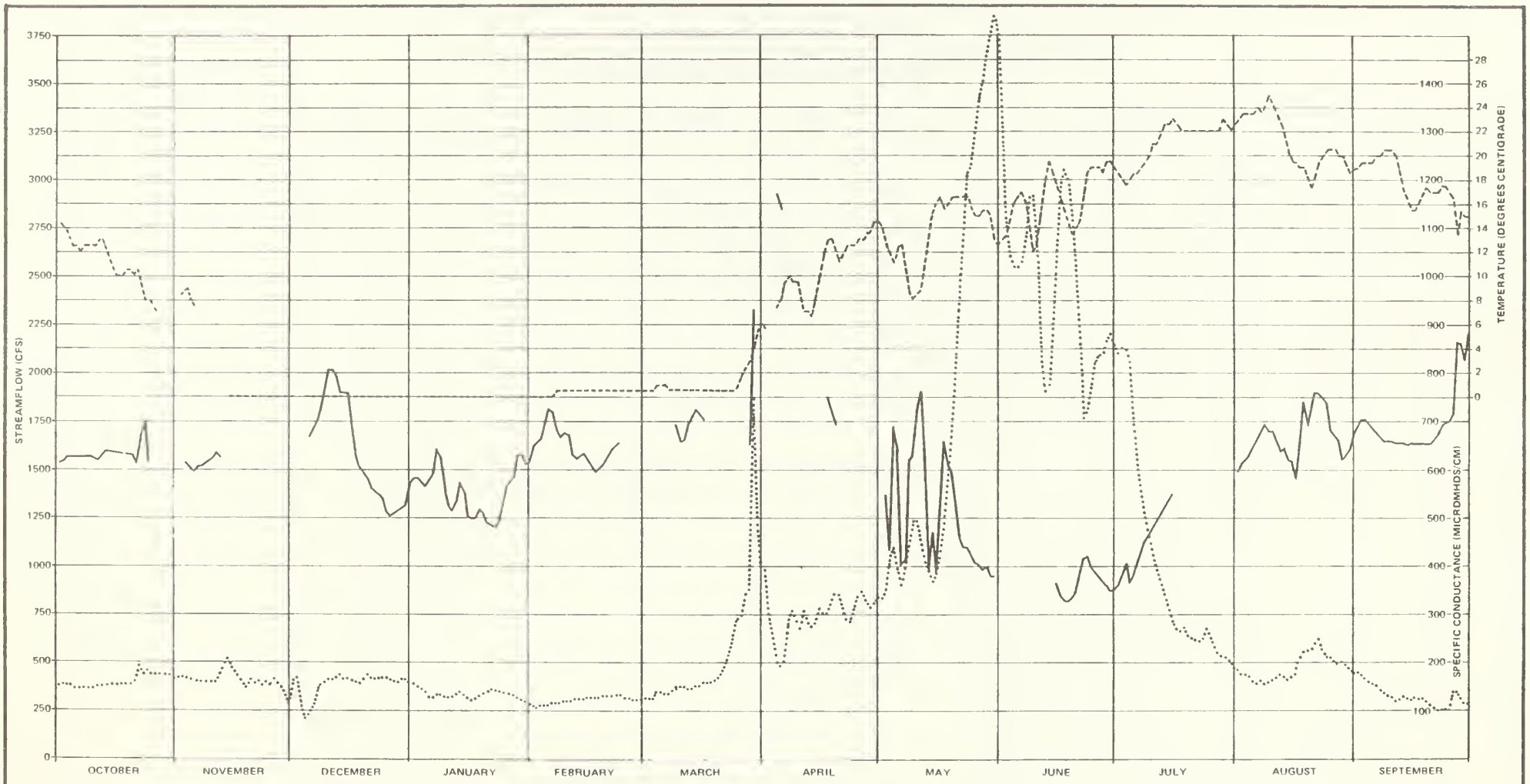
▲ INSTANTANEOUS SPECIFIC CONDUCTANCE

WHITE RIVER NEAR WATSON, UTAH (STA. 09306500)

MEAN DAILY STREAMFLOW AND INSTANTANEOUS TEMPERATURE AND SPECIFIC CONDUCTANCE

OCTOBER 1978 – SEPTEMBER 1979

FIGURE 4.1-8



LEGEND

STREAMFLOW
TEMPERATURE
SPECIFIC CONDUCTANCE

WHITE RIVER BELOW ASPHALT WASH, NEAR WATSON, UTAH (STA. 09306700)
MEAN DAILY STREAMFLOW, TEMPERATURE AND SPECIFIC CONDUCTANCE

OCTOBER 1978 – SEPTEMBER 1979

FIGURE 4.1-9

TABLE 4.1-7

WHITE RIVER NEAR COLORADO STATE LINE, UTAH (STA. NO. 09306395)
SUSPENDED SEDIMENT DISCHARGE
October 1977 - September 1978

DAY	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)
	OCTOBER		NOVEMBER		DECEMBER		JANUARY		FEBRUARY		MARCH	
1	220	111	---	640	---	320	---	240	---	240	---	480
2	210	98	---	550	---	350	---	210	---	240	---	470
3	210	107	---	540	---	300	---	160	---	240	---	470
4	205	99	---	580	---	300	---	110	---	240	---	470
5	210	96	---	550	---	330	---	130	---	240	---	520
6	3240	3240	---	540	---	310	---	210	---	230	---	610
7	23000	27000	---	980	300	250	---	250	---	230	---	860
8	11500	10200	---	710	---	180	---	230	---	230	---	920
9	2100	1640	690	670	---	230	---	200	---	260	---	1100
10	1430	1030	---	510	---	230	---	180	---	270	---	1100
11	820	558	---	410	---	180	---	190	---	210	---	1200
12	690	483	---	450	---	250	---	260	---	250	---	930
13	620	434	---	520	---	250	---	260	---	290	---	860
14	1000	783	---	500	---	240	---	250	---	290	---	840
15	790	593	---	460	---	240	---	170	---	290	---	830
16	780	602	---	450	---	240	---	200	---	260	730	733
17	900	734	---	450	---	240	---	200	---	230	---	650
18	800	635	---	450	---	240	244	201	---	200	---	680
19	540	417	---	420	---	91	---	200	---	170	---	990
20	660	510	---	340	---	91	---	200	---	120	---	1400
21	---	560	---	210	---	48	---	200	---	200	---	1900
22	---	580	---	66	---	24	---	200	256	200	---	1700
23	---	640	---	190	---	55	---	200	---	230	---	2400
24	---	580	---	530	---	71	---	200	---	220	---	3000
25	---	540	---	560	---	270	---	200	---	220	---	4500
26	---	520	---	570	---	250	---	230	---	280	---	1600
27	---	520	---	610	---	240	---	230	---	340	---	1100
28	---	520	---	530	---	230	---	230	---	440	---	1100
29	---	500	---	450	---	230	---	200	---	---	---	1100
30	---	550	---	400	---	250	---	150	---	---	---	1100
31	---	630	---	---	---	260	---	240	---	---	---	1200
TOTAL	---	55520	---	14875	---	5790	---	6331	---	6930	---	36813

TABLE 4.1-7 (cont.)

WHITE RIVER NEAR COLORADO STATE LINE, UTAH (STA. NO. 09306395)
SUSPENDED SEDIMENT DISCHARGE
October 1977 - September 1978

DAY	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)	MEAN CONCEN-TRATION (MG/L)	LOADS (T/DAY)
	APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER	
1	---	1500	---	4000	1710	10100	1040	6570	---	190	118	80
2	---	2300	---	3800	1880	10100	---	5700	---	200	102	70
3	---	2800	---	3400	2140	11800	---	4800	---	180	100	69
4	---	2200	---	4500	2180	12200	---	4300	---	160	91	62
5	---	1800	---	5700	2320	13800	---	3600	---	140	79	50
6	---	1900	---	5500	3130	20000	---	2900	---	140	61	35
7	---	1600	---	4700	2130	12300	---	2400	---	130	50	27
8	---	1400	---	4200	2270	13800	---	2200	---	120	61000	412000
9	---	1500	---	3800	1800	10800	---	1900	---	110	32600	5440
10	---	1700	---	3200	---	12000	---	1600	92	92	5050	5710
11	---	1600	---	3400	---	16000	---	1600	79	79	1100	1050
12	---	1400	---	3800	---	20000	---	1800	89	89	400	373
13	---	1400	---	3700	---	19000	---	1700	158	167	---	440
14	---	1600	---	4200	---	17000	550	1450	3100	3780	---	380
15	---	1700	---	7200	---	18000	---	1200	1380	1670	---	330
16	---	1700	---	16000	---	17000	---	1000	552	778	---	340
17	---	1800	---	27000	---	17000	---	960	270	339	---	340
18	---	1800	5680	37300	---	15000	---	1100	179	205	---	350
19	---	1600	4630	23300	1140	11100	---	1200	117	131	---	420
20	---	1400	3480	14300	1040	9580	---	980	155	184	410	486
21	---	1300	3170	13000	720	6240	---	840	169	198	395	459
22	---	1400	3570	16900	500	3970	---	710	208	233	---	460
23	---	1400	3640	18700	---	4900	---	600	252	265	---	420
24	---	1300	3890	23200	---	6000	---	430	223	219	---	410
25	---	1200	4230	30200	---	7300	---	490	194	180	---	380
26	980	1520	3400	23700	---	9000	---	410	175	166	---	380
27	---	2000	2680	16200	---	8800	---	330	141	128	---	370
28	---	3600	2700	16500	---	7100	---	270	150	131	---	340
29	---	3800	2340	12900	---	7200	---	240	149	131	---	350
30	---	4100	2500	13400	1120	7590	---	220	131	109	---	340
31	---	---	2200	12600	---	---	---	210	128	92	---	---
TOTAL	---	56320	---	380400	---	354680	---	53710	---	10736	---	431961

TOTAL LOAD FOR YEAR: 1415067 TONS.

NOTE: NUMBER OF MISSING DAYS OF RECORD EXCEEDED 20% OF YEAR

TABLE 4.1-8

WHITE RIVER NEAR COLORADO STATE LINE, UTAH (STA. NO. 09306395)
SUSPENDED SEDIMENT CONCENTRATION AND DISCHARGE MEASUREMENTS
October 1978 - September 1979

Date	Time	Temperature (°C)	Streamflow, Instantaneous (cfs)	Sediment, Suspended (mg/l)	Sediment Discharge, Suspended (tons/day)
02-27-79	1415	0.0	298	114	92
04-27-79	1545	11.0	860	2,980	6,920
06-01-79	1630	14.0	3,200	4,460	38,500
06-05-79	1345	17.0	2,570	2,800	19,400
06-06-79	1030	16.0	2,640	2,620	18,700
07-06-79	1600	19.0	1,570	1,010	4,280
08-08-79	1400	24.5	376	215	218
09-13-79	1550	18.5	318	80	69

TABLE 4.1-9

WHITE RIVER BELOW ASPHALT WASH, NEAR WATSON, UTAH (STA. NO. 09306700)
SUSPENDED SEDIMENT CONCENTRATION AND DISCHARGE MEASUREMENTS
October 1978 - September 1979

Date	Time	Temperature (°C)	Streamflow, Instantaneous (cfs)	Sediment, Suspended (mg/l)	Sediment Discharge, Suspended (tons/day)
10-02-78	1130	12.0	389	180	189
10-05-78	1200	10.0	361	185	180
10-10-78	1115	10.5	369	174	173
10-13-78	1030	10.5	389	181	190
10-17-78	1230	9.0	390	173	182
10-20-78	1045	9.0	385	170	177
10-24-78	1040	6.0	461	1,150	1,430
10-30-78	1100	6.5	430	196	228
11-03-78	1130	7.0	430	163	189
11-08-78	1035	5.0	400 E	168	181
11-14-78	1030	0.0	551	507	754
11-16-78	1245	0.0	430	335	389
11-21-78	1030	0.0	183	357	176
11-30-78	1230	0.0	313	232	196
12-04-78	1145	0.0	232	115	72
12-26-78	1415	0.0	408	94	104
01-10-79	1420	0.0	320 E	116	100
01-23-79	1330	0.0	350 E	119	112
02-23-79	1300	0.5	330 E	129	115
03-26-79	1330	2.5	726	4,450	8,720
04-04-79	1345	8.0	506	1,390	1,900
04-12-79	1150	6.5	685	3,420	6,330
04-20-79	1145	10.5	826	3,500	7,810
05-01-79	1400	14.0	826	1,690	3,770
05-21-79	1230	16.0	2,590	9,940	69,500
05-29-79	1130	14.0	3,710	5,600	56,100
06-05-79	1300	15.5	2,630	4,220	30,000
06-14-79	1300	18.0	2,340	2,110	13,300
06-25-79	1315	19.0	2,130	2,210	12,700

TABLE 4.1-9 (Continued)

WHITE RIVER BELOW ASPHALT WASH, NEAR WATSON, UTAH (STA. NO. 09306700)
SUSPENDED SEDIMENT CONCENTRATION AND DISCHARGE MEASUREMENTS
October 1978 - September 1979

Date	Time	Temperature (°C)	Streamflow, Instantaneous (cfs)	Sediment, Suspended (mg/l)	Sediment Discharge, Suspended (tons/day)
07-05-79	1230	17.0	1,760	1,550	7,370
07-12-79	1230	20.5	898	1,270	3,080
07-16-79	1130	22.0	685	739	1,370
08-02-79	1100	21.0	443	282	337
08-09-79	0915	23.0	405	359	393
08-16-79	1230	19.0	438	348	412
08-23-79	1020	18.5	585	1,970	3,110
08-28-79	1215	19.0	502	529	717
09-11-79	1300	16.5	302	192	157
09-28-79	1345	16.0	294	7,760	6,160

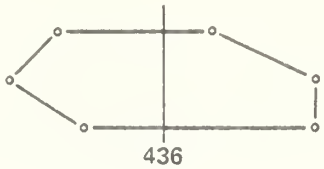
Note: The designation, E, means that the value was estimated.

Major Cations: The concentrations of calcium, magnesium, potassium, and sodium followed the same trend as dissolved solids. The values of Sodium Adsorption Ratio and percent of sodium also followed that trend. The limited number of values for strontium suggest that it also followed a similar trend.

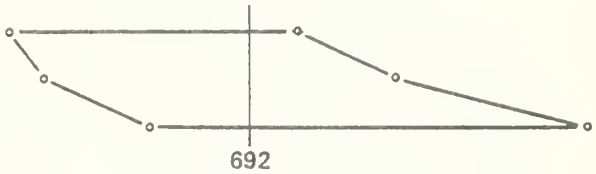
Major Anions: The bicarbonate and chloride concentrations followed an inverse relationship to streamflow, similar to that exhibited by alkalinity. The values of sulfate followed the same trend as dissolved solids. The concentration of fluoride was similar for all of the samples collected during the year, and ranged from 0.2 mg/l to 0.3 mg/l. Sulfide was not detected in the one sample in which it was analyzed (September 18). The bromide values were low during upper basin runoff (0.0 mg/l) and during baseflow (0.1 mg/l).

The distribution of the major ions for selected representative samples are shown in Figure 4.1-10. These Stiff diagrams clearly illustrate the variations of the major ions and dissolved solids in comparison to the source of streamflow. During both summer and winter baseflow, calcium was the dominant cation (by a marginal amount), and bicarbonate and sulfate were the dominant anions. During lower basin runoff, sodium was the dominant cation and sulfate was the dominant anion. These two ions illustrated large increases relative to the other ions from baseflow to lower basin runoff. The ion distribution for the sample collected during the transition of lower basin runoff to upper basin runoff is similar to that for baseflow samples. During upper basin runoff, the water is clearly a calcium-bicarbonate type.

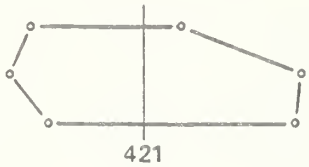
WINTER BASEFLOW
Station 6395
January 16, 1979



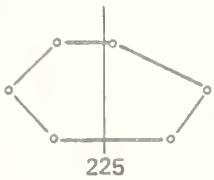
LOWER BASIN RUNOFF
Station 6500
March 30, 1979



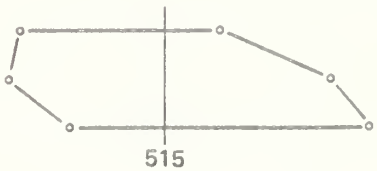
LOWER & UPPER BASIN RUNOFF
Station 6395
April 26, 1979



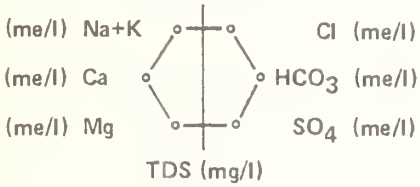
UPPER BASIN RUNOFF
Station 6395
June 6, 1979

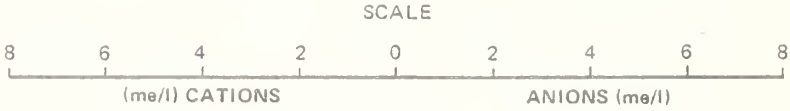


SUMMER BASEFLOW
Station 6395
September 18, 1979



LEGEND





DISTRIBUTION OF MAJOR IONS FOR SELECTED WHITE RIVER SAMPLES

OCTOBER 1978 – SEPTEMBER 1979

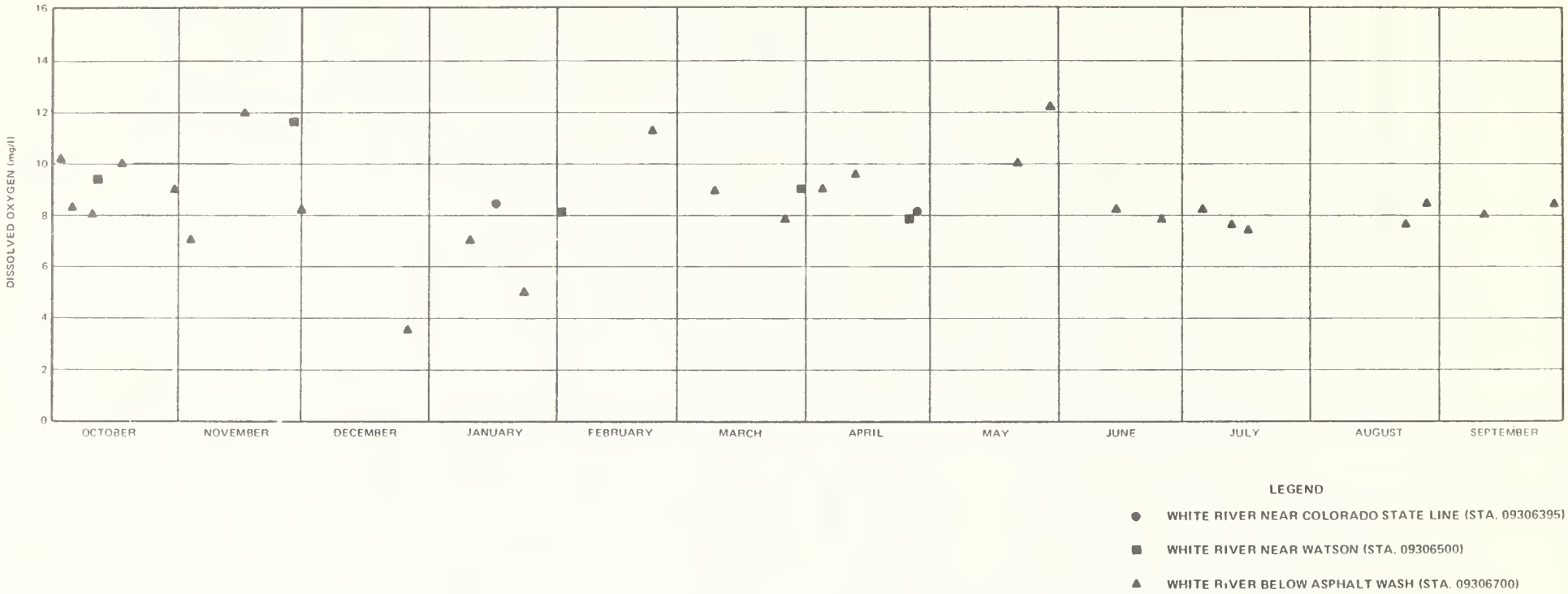
FIGURE 4.1-10

This results from significant decreases in the concentrations of sodium, magnesium, chloride and sulfate in this sample as compared to samples collected during baseflow and lower basin runoff.

Biochemical Constitutents: The variation in time of dissolved oxygen during the year is shown in Figure 4.1-11. The values shown for station 6700 are additional data not presented in Table 4.1-6. As indicated in the figure, the concentration of dissolved oxygen was highly variable, ranging from 3.5 mg/l to 12.2 mg/l. All but two values during the year were equal to or greater than 7.0 mg/l. These two values occurred at station 6700 on December 26 (3.5 mg/l) and January 23 (5.0 mg/l). The White River was totally ice covered at that time. This could have led to lower dissolved oxygen concentrations since the ice cover would have reduced aeration of the water.

The 1979 annual maximum value of 12.2 mg/l on May 29 at station 6700 is unusually high considering the water temperature (15.0°C). This unusual value could have been the result of the probe being out of calibration at the time. In general, the dissolved oxygen concentration was about 8 mg/l during the summer months when water temperature was highest, and about 10 to 12 mg/l in the fall and winter when the water temperature was lower, except for some depressed values from late November through early February.

The values of chemical oxygen demand, dissolved organic carbon, suspended total organic carbon, and total organic carbon for the September 18 sample are all about average for baseflow, in relation to the data from previous years. No other analyses of these constituents made during the year.



VARIATION IN TIME OF DISSOLVED OXYGEN

WHITE RIVER NEAR COLORADO STATE LINE TO BELOW ASPHALT WASH

OCTOBER 1978 – SEPTEMBER 1979

FIGURE 4.1-11

Macronutrients: Values of nitrite plus nitrate varied from 0.02 mg/l to 1.2 mg/l. The lower values occurred during baseflow and the maximum value occurred during lower basin runoff. The concentration of dissolved ortho-phosphorus was low throughout the year, ranging from 0.00 mg/l to 0.02 mg/l. The remaining macronutrients were analyzed only in the September 18 sample, and concentrations were generally about average for baseflow, in relation to data from previous years. The parameter name "total ammonia plus organic nitrogen as N" is the new nomenclature for what was previously termed "total kjeldahl nitrogen as N."

Micronutrients: The concentrations of dissolved boron varied from 40 ug/l to 150 ug/l. The minimum value occurred during upper basin runoff and the maximum value occurred during lower basin runoff. Dissolved iron concentrations ranged from 0 ug/l during baseflow to 120 ug/l during upper basin runoff. Values of dissolved manganese were variable during the year and ranged from 0 ug/l to 30 ug/l. The concentrations of copper and zinc were both about the same for the sample collected on June 5 during upper basin runoff as they were for the sample collected on September 18 during baseflow. Silica values ranged from 6.6 mg/l to 15 mg/l. The concentration of dissolved molybdenum was low (1 ug/l) in the June 5 sample. Dissolved cobalt was not detected in the September 18 sample.

Some additional analyses of the suspended and total phases of certain constituents were made for the September 18 sample. The results were variable and there are no previously collected data

available for comparison. The terms applicable to the dissolved, suspended, and total phases of a constituent are presented in the Glossary.

Trace Metals: The dissolved phase of these constituents was determined for the September 18 sample during baseflow and the June 5 sample during upper basin runoff. The data do not show any conclusive differences in the concentrations of these trace metals between the two sources of flow. Dissolved chromium and dissolved mercury were not detected in either sample.

The suspended and total phases of many of these trace metals were determined for the September 18 sample. Again, the data were variable, and no previously collected data are available for comparison.

Trace Non-Metals: The concentration of dissolved arsenic was the same (1 ug/l) during upper basin runoff as during baseflow. Phenols were low (1 ug/l) during baseflow.

Radioactive Constitutents: The values of the dissolved phase of gross alpha as natural uranium, gross beta as strontium-90/yttrium-90, and gross beta as cesium-137 for the September 18 samples were all below detection limits. Values for the suspended phase of these constituents for this sample were low in comparison to data collected in previous years.

Water Quality: Evacuation Creek (Station 6430)

The 1979 water quality data for station 6430 near the mouth of Evacuation Creek are summarized in Table 4.1-10. As in the summary of

TABLE 4.1-10

SUMMARY OF EVACUATION CREEK WATER QUALITY
STATION 09306430
October 1978-September 1979

		2/28/79 Baseflow	3/23/79 Highflow	4/30/79 Highflow	7/30/79 Baseflow	9/26/79 Baseflow
GENERAL CHARACTERISTICS						
Total Alkalinity as $CaCO_3$	(mg/l)	344	250	390	410	450
Dissolved Solids, calc. sum	(mg/l)	4030	1490	3570	3280	4710
Total Hardness as $CaCO_3$	(mg/l)	1100	440	1100	1100	1200
Noncarbonate Hardness as $CaCO_3$	(mg/l)	760	190	680	670	790
pH	(units)	7.8	8.2	8.0	8.0	8.0
Specific Conductance at 25°C	(umhos/cm)	4800	2020	4300	4100	5800
Streamflow, Instantaneous	(cfs)	0.02	4.0	est. 1.3	0.12	0.08
Temperature	(°C)	0.2	10.0	19.5	23.5	13.5
MAJOR CATIONS						
Calcium, dissolved	(mg/l)	160	85	150	170	150
Magnesium, dissolved	(mg/l)	180	55	170	160	210
Potassium, dissolved	(mg/l)	8.8	5.2	8.0	8.9	11
Sodium, dissolved	(mg/l)	900	320	780	700	990
Sodium Adsorption Ratio		12	6.7	10	9.3	12
Percent Sodium		63	61	61	58	63
Strontium, dissolved	(ug/l)	--	--	--	--	4100

TABLE 4.1-10 (cont.)

SUMMARY OF EVACUATION CREEK WATER QUALITY
STATION 09306430
October 1978-September 1979

		2/28/79 Baseflow	3/23/79 Highflow	4/30/79 Highflow	7/30/79 Baseflow	9/26/79 Baseflow
MAJOR ANIONS						
Bicarbonate	(mg/l)	420	305	475*	500*	549*
Carbonate	(mg/l)	0*	0*	0*	0*	0*
Chloride, dissolved	(mg/l)	59	20	6.1	83	59
Sulfate, dissolved	(mg/l)	2500	840	2200	1900	3000
Sulfide as S, total	(mg/l)	--	--	--	--	0.0
Bromide, dissolved	(mg/l)	--	--	--	--	0.4
Fluoride, dissolved	(mg/l)	0.7	0.6	0.9	2.3	0.8
BIOCHEMICAL CONSTITUENTS						
Dissolved Oxygen	(mg/l)	8.0	--	4.6	6.0	--
Chemical Oxygen Demand	(mg/l)	--	--	36	--	45
Organic Carbon, dissolved	(mg/l)	--	--	--	--	19
MACRONUTRIENTS						
Ammonia as N, dissolved	(mg/l)	-	-	0.01	--	0.00
Nitrite plus Nitrate as N, dissolved	(mg/l)	0.02	1.7	2.9	0.70	0.49
Ammonia plus Organic Nitrogen as N, total	(mg/l)	--	--	3.2		0.96
Total Phosphorus as P	(mg/l)	--	--	0.01	--	0.03
Ortho-Phosphorus as P, dissolved	(mgl)	0.03	--	0.00	0.00	0.03

TABLE 4.1-10 (cont.)

SUMMARY OF EVACUATION CREEK WATER QUALITY
STATION 09306430
October 1978-September 1979

		2/28/79 Baseflow	3/23/79 Highflow	4/30/79 Highflow	7/30/79 Baseflow	9/26/79 Baseflow
MICRONUTRIENTS						
Boron, dissolved	(ug/l)	2200	440	1800	1900	2400
Copper, dissolved	(ug/l)	--	--	0	--	0
Iron, dissolved	(ug/l)	30	--	60	10	40
Manganese, dissolved	(ug/l)	320	--	90	60	290
Zinc, dissolved	(ug/l)	--	--	30	--	40
Molybdenum, dissolved	(ug/l)	--	--	--	--	38
Silica as SiO_2, dissolved	(mg/l)	10	6.1	9.8	6.8	11
TRACE METALS						
Aluminum, dissolved	(ug/l)	--	40	10	--	10
Barium, dissolved	(ug/l)	--	--	--	--	100
Cadmium, dissolved	(ug/l)	--	--	0	--	0
Chromium, dissolved	(ug/l)	--	--	20	--	20
Lead, dissolved	(ug/l)	--	--	0	--	0
Lithium, dissolved	(ug/l)	--	--	--	--	150
Mercury, dissolved	(ug/l)	--	--	0.0	--	0.0
Selenium, dissolved	(ug/l)	--	--	4	--	1
Vanadium, dissolved	(ug/l)	--	--	--	--	0.0

TABLE 4.1-10 (cont.)

SUMMARY OF EVACUATION CREEK WATER QUALITY
STATION 09306430
October 1978-September 1979

TRACE NON-METALS		2/28/79 Baseflow	3/23/79 Highflow	4/30/79 Highflow	7/30/79 Baseflow	9/26/79 Baseflow
Arsenic, dissolved	(ug/l)	--	--	1	--	1
Phenols	(ug/l)	--	--	--	--	4

* Value calculated by VTN

Abbreviations:

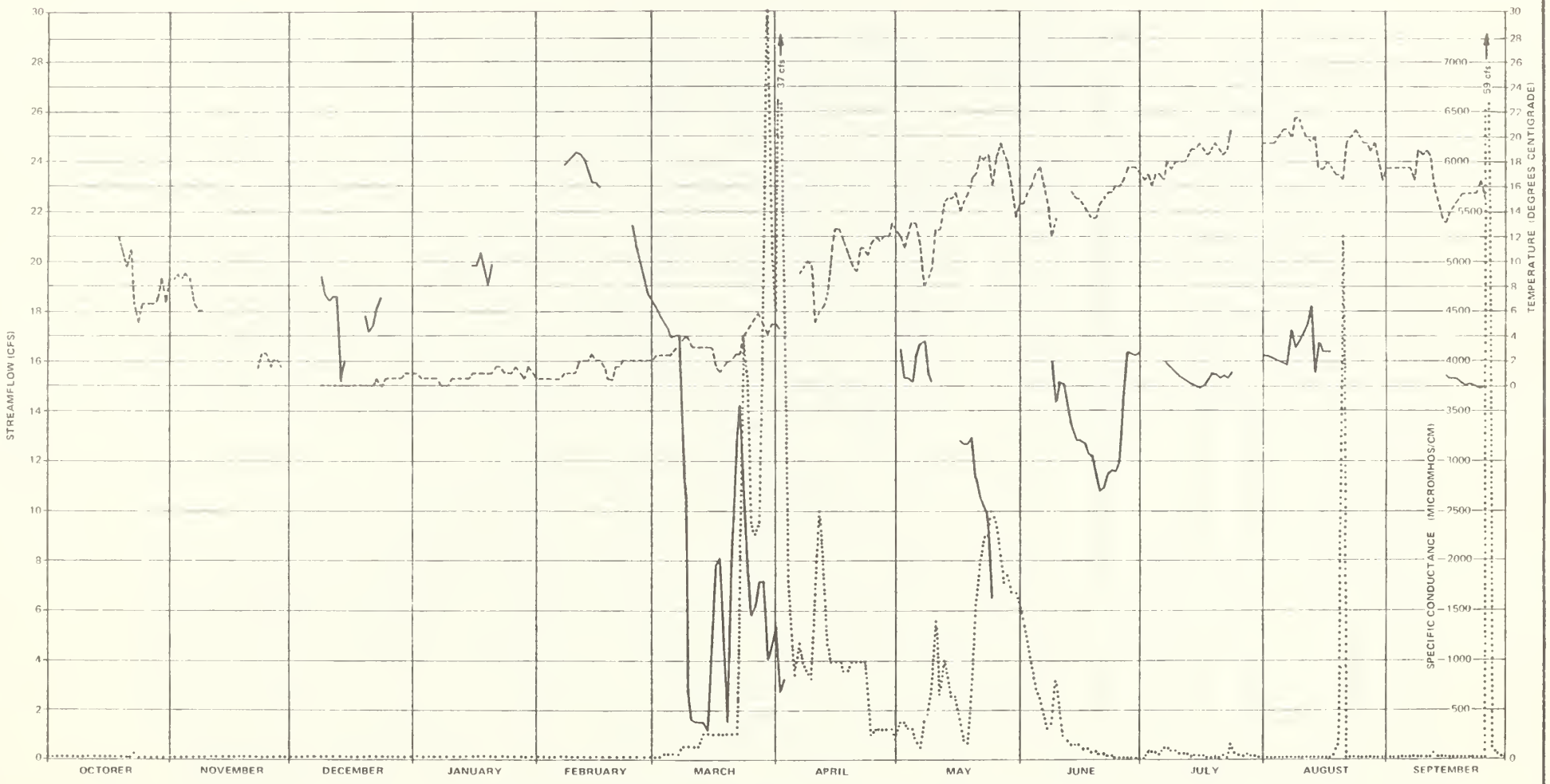
calc. = calculated
est. = estimated

White River water quality, the type of flow is shown below the date of sample collection. Highflow is defined as the period of time when surface runoff contributes a significant portion of the streamflow of Evacuation Creek. Baseflow is the period of time when ground water discharge sustains the streamflow of Evacuation Creek. It should be noted that the September 26 sample was collected early in the day prior to the flash flood of that day which was discussed earlier. The parameters in Table 4.1-10 have been grouped according to general categories.

General Characteristics: The concentration of dissolved solids ranged from 1,490 mg/l during snowmelt runoff in March to 4,710 mg/l during later summer baseflow. Generally, the dissolved solids concentration illustrated an inverse relationship to streamflow. However, this relationship varied considerably depending on the climatic and hydrologic conditions that existed prior to sample collection. For instance, the April 30 sample was collected during the recession from spring snowmelt and rainfall runoff. It is probable that there was a considerable ground water contribution to the streamflow, due to release from bank storage as well as discharges from the Bird's Nest aquifer. This effect is illustrated by the large increase in dissolved solids concentration compared to the value for the March sample. The July 30 sample was collected a few days after a period of increased streamflow due to rainfall runoff. The dissolved solids concentration for this sample was somewhat lower than for the other baseflow samples, even though streamflow was similar for all three samples.

The pH values shown in Table 4.1-10 were similar for all five sample dates. Additional field readings taken on other days during the year varied from 7.0 to 9.0. Total alkalinity and total hardness ranged from 250 mg/l to 450 mg/l and 440 mg/l to 1,200 mg/l, respectively. Both of these constituents follow trends similar to the variation of dissolved solids.

The variations of mean daily streamflow, temperature and specific conductance are shown in Figure 4.1-12. Temperature generally followed an annual sinusoidal pattern. The range of instantaneous temperature readings during the year was 0.0°C to 34.0°C, with an annual mean value of 9.5°C. The recorded diurnal variation of water temperature reached values up to 23°C during the summer months. Specific conductance generally followed an inverse relation to streamflow, but showed large variations from this trend for short periods of time. The number of days of record amounted to only 42% of the year. The range of instantaneous readings during the year was 90 micromhos/cm to 9,600 micromhos/cm. This minimum value occurred in March when the ice buildup in the streambed was melting but snowmelt runoff in the drainage had not yet begun. The maximum value occurred during the rapid rise in stage for the flow event on September 26, and was caused by the initial flushing of salts from the soil by surface runoff. It is likely that these minimum and maximum values for the days of record were not exceeded during the missing days of record. Therefore, they should also represent the 1979 annual instantaneous minimum and maximum values of specific conductance.



LEGEND:

STREAMFLOW

TEMPERATURE

SPECIFIC CONDUCTANCE

EVACUATION CREEK NEAR WATSON, UTAH (STATION NO. 09306430)

MEAN DAILY STREAMFLOW, TEMPERATURE AND SPECIFIC CONDUCTANCE

OCTOBER 1978 – SEPTEMBER 1979

FIGURE 4.1-12

The values of instantaneous suspended sediment concentration and discharge during the 1979 water year are shown in Table 4.1-11. The mean daily values were estimated from these measurements. The monthly and annual summary is shown in Table 4.1-12. The maximum mean daily suspended sediment discharge was estimated to have been 32,000 tons/day on September 26. The total annual discharge was estimated to have been 55,375 tons. Most of the suspended sediment load during the year was carried by the flash flood on September 26.

Major Cations and Anions: The distribution of major ions for each of the five samples collected during the year is shown in Figure 4.1-13. This figure illustrates that sodium and sulfate were the dominant cation and anion, respectively, for all of the samples. Generally, the variations of all of these major ions were similar to the variation of dissolved solids; i.e., values were lowest during snowmelt runoff in March and highest during late summer baseflow in September. The concentration of fluoride varied from 0.6 mg/l to 2.3 mg/l. Sulfide and bromide values for the September 26 sample were 0.0 mg/l and 0.4 mg/l.

Biochemical Constituents: Several field readings of dissolved oxygen, in addition to those shown in Table 4.1-10, were made during the year. The values ranged from 4.6 mg/l to 13.0 mg/l. Chemical oxygen demand was 36 mg/l for the April 30 sample and 45 mg/l for the September 26 sample. Dissolved organic carbon was 19 mg/l for the September 26 sample.

TABLE 4.1-11

EVACUATION CREEK NEAR WATSON, UTAH (STA. NO. 09306430)
SUSPENDED SEDIMENT CONCENTRATION AND DISCHARGE MEASUREMENTS
October 1978 - September 1979

Date	Time	Temperature (°C)	Streamflow, Instantaneous (cfs)	Sediment, Suspended (mg/l)	Sediment Discharge, Suspended (tons/day)
02-16-79	1045	1.5	0.02	51	< 0.01
02-26-79	1200	0.0	0.05	36	< 0.01
03-06-79	1330	3.0	0.20	46	0.02
03-15-79	1035	2.5	1.0	16	0.04
03-22-79	1030	2.0	4.4	7,490	89
03-29-79	1105	3.5	47	65,400	8,300
04-05-79	1045	8.0	3.4	1,310	12
04-13-79	1000	5.0	5.3	3,180	46
04-23-79	1340	17.5	1.4	609	2.3
04-30-79	1315	19.5	1.3	141	0.49
05-09-79	1315	13.0	3.1	715	6.0
05-15-79	1230	19.0	3.0	855	6.9
05-22-79	1230	19.0	9.7	11,600	304
05-30-79	1130	13.5	6.7	5,430	98
06-07-79	1230	18.0	1.5	327	1.3
06-12-79	1100	20.0	0.91	221	0.54
07-17-79	1205	23.0	0.14	389	0.15
07-30-79	1100	23.5	0.12	234	0.08
08-14-79	0945	15.5	0.09	310	0.08
08-22-79	1045	18.0	0.09	454	0.11
09-07-79	1000	11.0	0.07	16	< 0.01

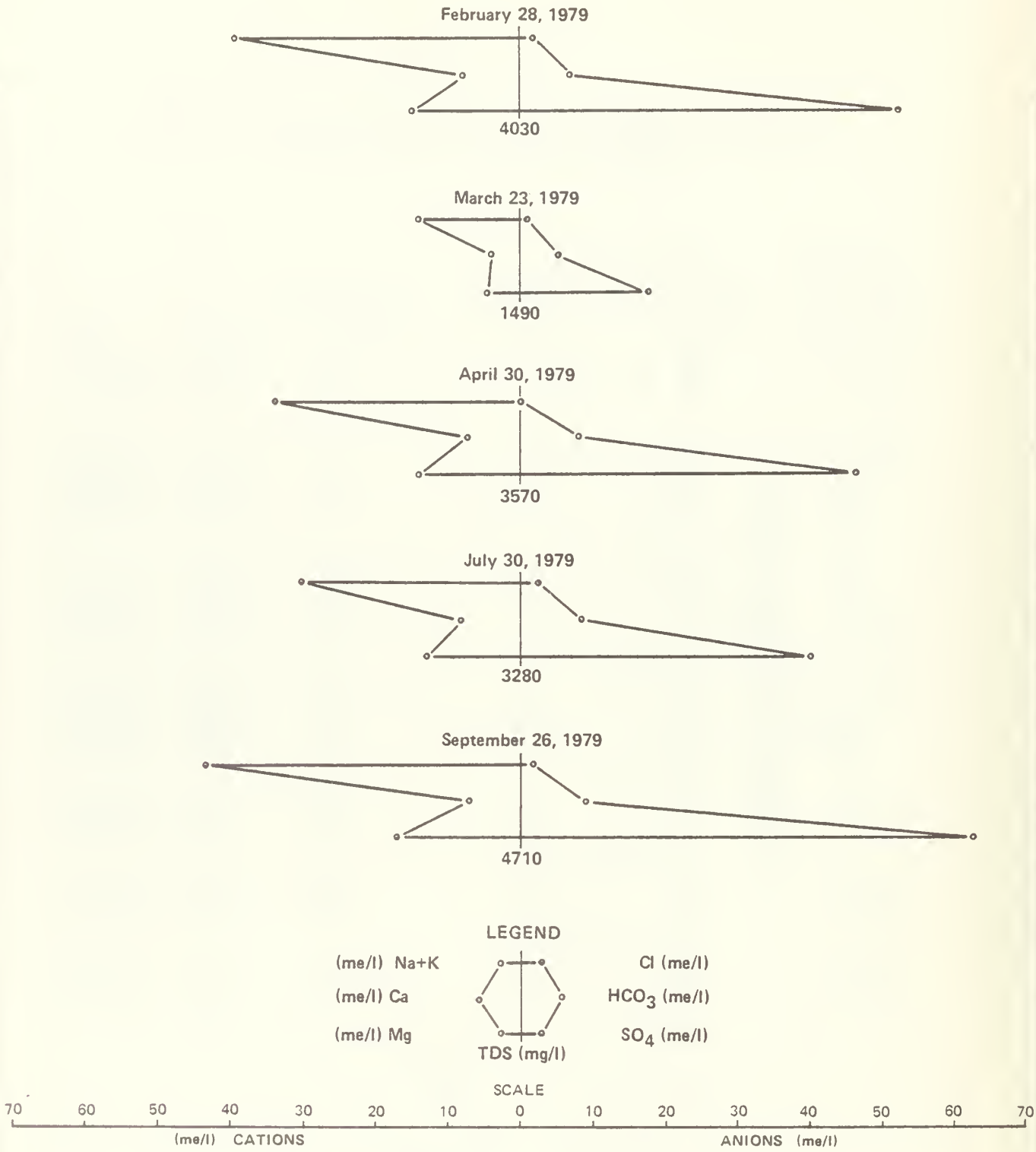
TABLE 4.1-12

EVACUATION CREEK NEAR WATSON (STA. NO. 09306430)
SUSPENDED SEDIMENT DISCHARGE (TONS/DAY)
October 1978 - September 1979

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep
Total	0.88	0.00	0.00	0.00	0.09	9,463.68	6,898.80	2,193.79	152.86	31.69	4,584.76	32,048.38
Maximum	0.72	0.00	0.00	0.00	0.01	3,600	4,900	320	62	9.0	4,400	32,000
Minimum	0.00	0.00	0.00	0.00	0.00	0.01	0.30	0.10	0.00	0.00	0.00	0.00

Water Year 1979

Total	55,374.93
Maximum	32,000
Minimum	0.00



DISTRIBUTION OF MAJOR IONS FOR EVACUATION CREEK (STATION 6430)

OCTOBER 1978 – SEPTEMBER 1979

FIGURE 4.1-13

Macronutrients: Dissolved nitrite plus nitrate varied from 0.02 mg/l to 2.9 mg/l, with the March 23 and April 30 samples exhibiting the higher values. Total ammonia plus organic nitrogen was also higher for the April 30 sample than for the September 26 sample. The remaining macronutrients showed little variation during the year.

Micronutrients: Dissolved boron concentrations varied from 440 ug/l during highflow on March 23 to 2,400 ug/l during late summer baseflow on September 26. The concentration of dissolved silica ranged from 6.1 mg/l to 11 mg/l. Dissolved manganese varied from 60 ug/l to 320 ug/l. The concentrations of the rest of the micronutrients showed little variation and were similar to data collected during previous years.

Trace Metals: All of the dissolved trace metals remained at levels similar to data collected during previous years.

Trace Non-Metals: Arsenic and phenols also remained at levels similar to data collected during previous years.

Water Quality: Dry Washes

The water quality data from samples collected at stations 6405 (Hell's Hole Canyon), 6610 (Southam Canyon), and 6625 (Asphalt Wash) during the 1979 water year are shown in Table 4.1-13. All of the samples were collected during snowmelt runoff in late March. The parameters have been grouped according to general categories.

TABLE 4.1-13

SUMMARY OF DRY WASHES WATER QUALITY
October 1978 - September 1979

		Sta. 6405 3/30/79	Sta. 6610 3/28/79	Sta. 6610 3/31/79	Sta. 6625 3/30/79
GENERAL CHARACTERISTICS					
Total Alkalinity as $CaCO_3$	(mg/l)	410	170	189	160
Dissolved Solids, Residue at 180°C	(mg/l)	560	--	1010	1380
Dissolved Solids, calc. sum	(mg/l)	743	613	999	1330
Total Hardness as $CaCO_3$	(mg/l)	350	190	220	230
Noncarbonate Hardness as $CaCO_3$	(mg/l)	0	23	31	70
pH	(units)	8.3	8.0	7.9	7.4
Specific Conductance at 25°C	(umhos/cm)	710	750	1480	1920
Streamflow, Instantaneous	(cfs)	2.3	0.91	1.0 est.	8.3
Temperature	(°C)	10.0	6.5	10.0	11.5
MAJOR CATIONS					
Calcium, dissolved	(mg/l)	100	69	79	67
Magnesium, dissolved	(mg/l)	23	4.7	6.2	15
Potassium, dissolved	(mg/l)	6.7	3.8	4.0	2.9
Sodium, dissolved	(mg/l)	130	130	250	360
Sodium Adsorption Ratio		3.0	4.1	7.3	10
Percent Sodium		45	59	70	77
Strontium, dissolved	(ug/l)	900	1100	1300	1600

TABLE 4.1-13 (cont.)

SUMMARY OF DRY WASHES WATER QUALITY
October 1978 - September 1979

		Sta. 6405 3/30/79	Sta. 6610 3/28/79	Sta. 6610 3/31/79	Sta. 6625 3/30/79
MICRONUTRIENTS					
Boron, dissolved	(ug/l)	360	80	110	230
Copper, dissolved	(ug/l)	--	40	--	--
Iron, dissolved	(ug/l)	10	210	10	40
Manganese, dissolved	(ug/l)	10	0	10	260
Zinc, dissolved	(ug/l)	--	30	--	--
Molybdenum, dissolved	(ug/l)	30	16	25	25
Silica as SiO_2, dissolved	(mg/l)	6.9	10	16	10
TRACE METALS					
Aluminum, dissolved	(ug/l)	0	180	0	50
Barium, dissolved	(ug/l)	--	200	--	--
Cadmium, dissolved	(ug/l)	--	0	--	--
Chromium, dissolved	(ug/l)	--	0	--	--
Lead, dissolved	(ug/l)	--	0	--	--
Lithium, dissolved	(ug/l)	--	20	--	--
Mercury, dissolved	(ug/l)	--	0.0	--	--
Selenium, dissolved	(ug/l)	--	2	--	--
Vanadium, dissolved	(ug/l)	--	12	--	--

TABLE 4.1-13 (cont.)

SUMMARY OF DRY WASHES WATER QUALITY
October 1978 - September 1979

		Sta. 6405 3/30/79	Sta. 6610 3/28/79	Sta. 6610 3/31/79	Sta. 6625 3/30/79
MAJOR ANIONS					
Bicarbonate	(mg/l)	500*	207*	230	195
Carbonate	(mg/l)	0*	0*	0*	0*
Chloride, dissolved	(mg/l)	7.8	13	28	34
Sulfate, dissolved	(mg/l)	220	270	500	740
Sulfide as S, total	(mg/l)	--	0.0	--	--
Bromide, dissolved	(mg/l)	--	0.1	--	--
Fluoride, dissolved	(mg/l)	0.8	0.9	0.6	0.9
BIOCHEMICAL CONSTITUENTS					
Dissolved Oxygen	(mg/l)	--	8.6	--	--
Chemical Oxygen Demand	(mg/l)	--	990	--	--
Organic Carbon, dissolved	(mg/l)	--	5.0	--	--
MACRONUTRIENTS					
Ammonia as N, dissolved	(mg/l)	--	0.07	--	--
Nitrite plus Nitrate as N, dissolved	(mg/l)	--	1.5	--	--
Ammonia plus Organic Nitrogen as N, total	(mg/l)	--	30	--	--
Total Phosphorus as P	(mg/l)	--	1.8	--	--
Ortho-Phosphorus as P, dissolved	(mgl)	--	0.08	--	--

TABLE 4.1-13 (cont.)

SUMMARY OF DRY WASHES WATER QUALITY
October 1978 - September 1979

		Sta. 6405 3/30/79	Sta. 6610 3/28/79	Sta. 6610 3/31/79	Sta. 6625 3/30/79
TRACE NON-METALS					
Arsenic, dissolved	(ug/l)	--	7	--	--
MBAS	(mg/l)	--	0.00	--	--
Phenols	(ug/l)	--	8	--	--

* Value calculated by VTN

Abbreviations:

calc. = calculated
est. = estimated

General Characteristics: The concentration of dissolved solids varied from 613 mg/l to 1330 mg/l for the March 1979 samples. The pH values varied from 7.4 to 8.3. The ranges of total alkalinity and total hardness were 160 mg/l to 410 mg/l and 190 mg/l to 350 mg/l. These parameters showed considerable variation between stations.

Temperature values obtained during collection of the four samples ranged from 6.5°C to 11.5°C. The continuous recorder at station 6610 at the mouth of Southam Canyon indicated that the water temperature varied from 3.0°C to 15.0°C during the period March 28 through April 1. The temperature record at this station on September 26 ranged from 7.5°C to 9.5°C, but the record was incomplete because silt quickly covered the probe. The specific conductance values obtained during collection of the four samples varied from 710 micromhos/cm to 1330 micromhos/cm and as expected, illustrated a direct relationship to dissolved solids concentration. The continuous record at station 6610 during the period March 28 through April 1 ranged from 540 micromhos/cm to 2100 micromhos/cm. On September 26, the record ranged from 580 micromhos/cm to 590 micromhos/ cm. These continuous records of specific conductance were not complete because the probe was covered with silt much of the time.

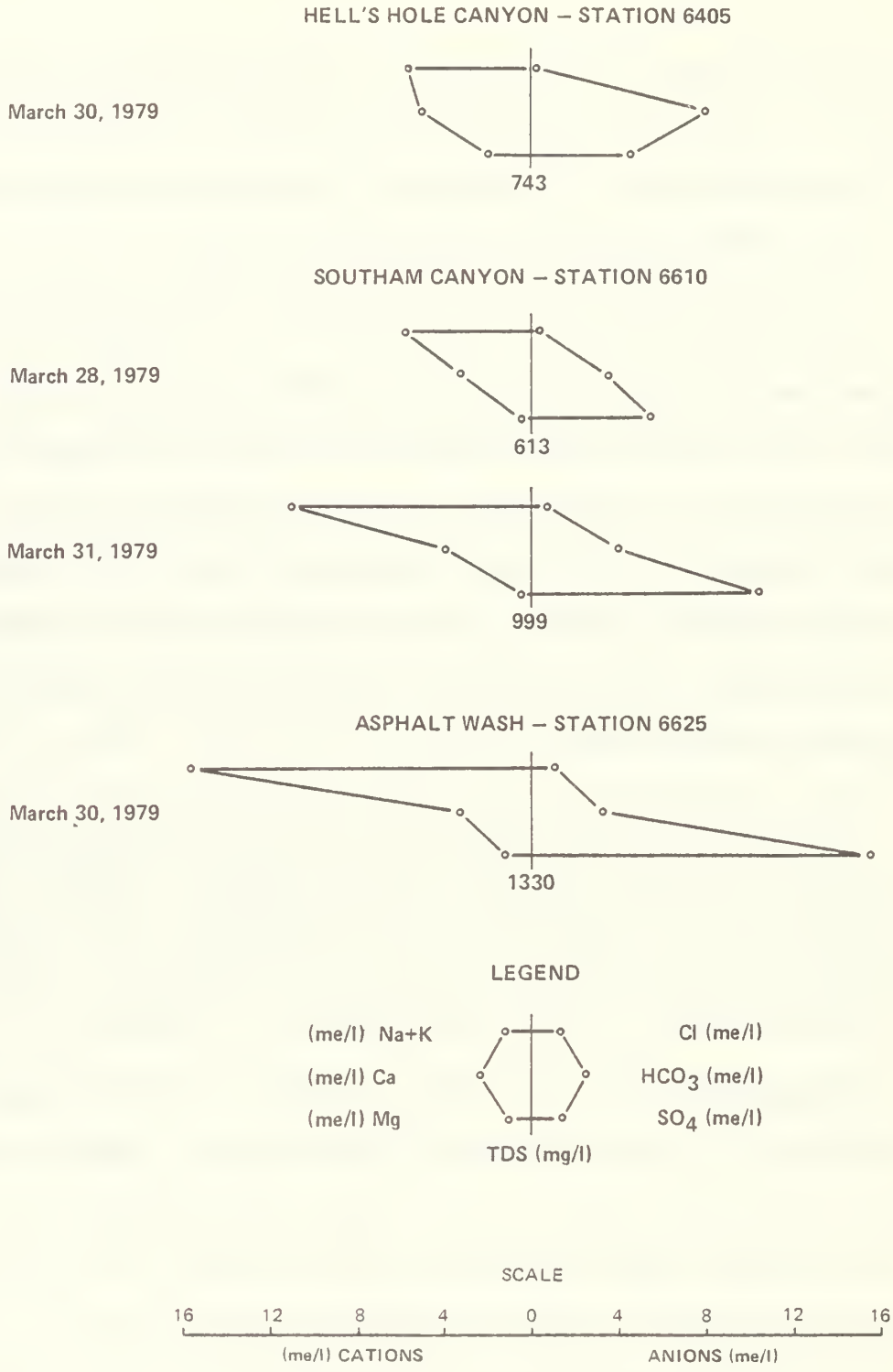
Suspended sediment samples were collected during the year at station 6610 but not at stations 6405 and 6625. Suspended sediment discharge at station 6610 during the period March 28 through April 1 was estimated to have been 9.30 tons. The suspended sediment discharge on September 26 was estimated to have been 4900 tons. This daily value

was based on samples collected by the single-stage sampler during the flow event. These samples had an average suspended sediment concentration of 389,000 mg/l. The annual total suspended sediment discharge at station 6610 was estimated to have been 4909 tons.

Major Cations and Anions: The distribution of the major ions for each of the four samples collected during 1979 is shown in Figure 4.1-14. These Stiff diagrams illustrate the variations between the three dry washes. For the sample at station 6405 in Hell's Hole Canyon, the dominant cations were sodium and calcium, and the dominant anion was bicarbonate. For the samples at stations 6610 in Southam Canyon and 6625 in Asphalt Wash, the dominant cation was sodium and the dominant anion was sulfate.

The values of Sodium Adsorption Ratio and the percent of sodium also showed considerable variation between stations. Dissolved strontium concentrations ranged from 900 ug/l to 1600 ug/l. The dissolved fluoride concentrations ranged from 0.6 mg/l to 0.9 mg/l.

Biochemical Constituents: The only value of dissolved oxygen collected was 8.6 mg/l for station 6610 on March 28. Chemical oxygen demand at this station was very high on this date (990 mg/l), while the dissolved organic carbon concentration was relatively low (5.0 mg/l). Since total organic carbon was not analyzed, there is no way to be sure if this may have caused the high COD value, but it is likely that the COD value could have been associated with a high concentration of total organic carbon.



DISTRIBUTION OF MAJOR IONS FOR DRY WASHES (STATIONS 6405, 6610 AND 6625)

OCTOBER 1978 – SEPTEMBER 1979

FIGURE 4.1-14

Macronutrients: Concentrations of dissolved nitrite plus nitrate (1.5 mg/l), total ammonia plus organic nitrogen (30 mg/l), and total phosphorus (1.8 mg/l) in the sample discussed above were also relatively high, while concentrations of dissolved ammonia (0.07 mg/l) and dissolved ortho-phosphorus (0.08 mg/l) were relatively low.

Micronutrients: The concentrations of most of these constituents illustrated considerable variation between the stations on the three dry washes. Many of the values also illustrated considerable variation from the data collected during the Baseline period at these stations.

Trace Metals and Non-Metals: These constituents, with the exception of dissolved aluminum, were analyzed only for the March 28 sample at station 6610. During the Baseline period, these constituents were also analyzed only once (June 22, 1976) at this station. The two sets of data are generally similar.

4.1.1.4 Conclusions. The 1979 work plan was concerned with: 1) comparisons of physical and chemical composition of the surface water between the White River monitoring stations during the most recent water year; and 2) comparison of the physical and chemical composition of the surface water at all of the monitoring stations between the 1979 water year and the previous water years, especially the Baseline period. The purpose of these comparisons is to check for significant differences between the sets of data, so that the continuity between the Baseline period and future monitoring periods is maintained.

Comparison of Physical and Chemical Composition of the Surface Water Between the White River Monitoring Stations (6395, 6500, and 6700) During the 1979 Water Year

The streamflow data for the White River stations showed very little variation between the stations during the year. There was a small increase (0.8%) in total annual runoff from station 6395 (upstream of the tracts) to station 6700 (downstream of the tracts).

The work plan for the 1979 water year did not include the collection of water quality samples for laboratory analysis at station 6700. This was done because the previous four years of laboratory water quality data had indicated that there were no significant differences in water quality between the White River monitoring stations. The rationale was that the continuous records of temperature and specific conductance, plus the data concerning suspended sediment, pH, and dissolved oxygen at stations 6395 and 6700 should adequately indicate any change in the relationship between the stations. Water quality samples were collected on a quarterly basis during the year at station 6395 in order to define the chemical composition of the White River as it passed by the tracts. The USGS did continue to collect water quality samples during the 1979 water year at station 6500 for their own study program, but the samples were analyzed for fewer constituents than for station 6395.

A comparison of the available 1979 records of temperature and specific conductance at the three White River stations indicates that both parameters showed little variation between the stations.

Inspection of the available suspended sediment records for stations 6395 and 6700 during the 1979 water year indicates that suspended

sediment concentration and discharge were generally greater at station 6700 (downstream of the tracts) than at station 6395 (upstream of the tracts). During the winter, the values of suspended sediment concentration and discharge were relatively similar between the two stations. However, during the peak flow period, these values were considerably greater at the downstream station. This condition also occurred during at least a portion of the late summer baseflow period.

The differences in suspended sediment concentration and discharge between the upstream and downstream stations appears to be somewhat greater than can be accounted for by considering the contributions from the tributaries between the two stations. One possible explanation for this condition is that the White River channel between the two stations may have been in an overall state of erosion; i.e., the streamflow was removing more sediment from the channel itself than was being deposited.

An alternate explanation is that the increased sediment load at station 6700 may have been a local phenomenon caused by the temporary suspension of sediment eroded from the reach immediately upstream of the sampling location. The rate of channel migration of the White River during a particular year relates to the total annual flow. Of course, the greatest channel migration generally occurs during years that have a total annual flow which is greater than normal. The total annual flow during the 1979 water year was greater than normal, and considerable stream bank and channel erosion did occur at and immediately upstream of station 6700. It is possible that this condition caused the suspended sediment concentration at the sampling location to

be somewhat higher than the average concentration that would have been observed over a longer reach (approximately one mile) above and below station 6700.

The actual causes for the difference in suspended sediment discharge between the two stations are probably related to one or both of the above explanations, as well as other unknown factors.

Two concurrent sets of water quality samples were collected at stations 6395 and 6500 during the year. These occurred on April 26 during the transition from lower basin runoff to upper basin runoff, and on June 6 during upper basin runoff. Inspection of these data indicates that the water quality at these two stations was similar for the parameters analyzed. Also, the field data for pH and dissolved oxygen at station 6700 during the year were similar to the data collected at stations 6395 and 6500, with the exception of some unusual dissolved oxygen values which occurred during the winter at station 6700.

In summary, the available data indicate that there was little variation in the physical and chemical composition of the surface water between the White River stations during the 1979 water year, except for suspended sediment values. The suspended sediment data indicate significantly greater levels at the downstream station, especially during the peak flow period. The measurements at the downstream station appear to have been influenced by local hydraulic conditions which may have increased the suspended sediment concentrations at the sampling location during certain portions of the year.

Comparison of Physical and Chemical Composition of the Surface Water Between the 1979 Water Year and Previous Years of Record (1975-1978)

White River

The flow regime during the 1979 water year was similar to the regime during the Baseline period (1975 and 1976 water years). Table 4.1-14 summarizes the streamflow records at station 6500 during each of the five years of the Baseline and Interim periods, as well as the period of record at this station (water years 1923 through 1979). It is apparent from this table that the mean, maximum and minimum values of discharge and total annual runoff for the 1979 water year are within the range of values from the previous four years of monitoring. The 1979 annual runoff (68,460 hectare-meters [555,000 acre-feet]) was slightly greater than the average annual runoff for the period of record (62,100 hectare-meters [503,500 acre-feet]). This was primarily due to greater than normal snowmelt runoff from the lower and upper drainage basins.

The temperature and specific conductance records during the 1979 water year were similar to the records during the previous four years. The 1979 annual maximum and minimum mean daily values at station 6700 were within previously observed ranges.

The suspended sediment records during the 1979 water year were generally similar to the records during the previous four years. The 1979 annual maximum and minimum instantaneous values of suspended sediment concentration and discharge at stations 6395 and 6700 were within previously observed ranges.

TABLE 4.1-14

SUMMARY OF STREAMFLOW RECORDS
White River near Watson, Utah (Station 09306500)
Water Years 1975 - 1979 vs. Period of Record

		1975 Water Year	1976 Water Year	1977 Water Year	1978 Water Year	1979 Water Year	Period of Record
Mean Daily Discharge	(cms)	21.8	15.5	8.72	20.8	21.7	19.7
	(cfs)	772	546	308	735	767	695
Maximum Daily Discharge	(cms)	111	58.0	17.0	108	108	231*
	(cfs)	3910	2050	602	3800	3820	8160*
Maximum Instantaneous Discharge	(cms)	118	60.9	37.1	111	110	--*
	(cfs)	4150	2150	1310	3910	3900	--*
Minimum Daily Discharge	(cms)	4.81	4.90	0.37	2.72	5.38	0.37
	(cfs)	170	173	13	96	190	13
Minimum Instantaneous Discharge	(cms)	3.06	4.73	0.34	2.69	--	0.31
	(cfs)	108	167	12	95	--	11
Total Annual Runoff	(ha-m)	68,930	48,930	27,530	65,660	68,460	62,100
	(ac-ft)	558,800	396,700	223,300	532,300	555,000	503,500

*Note: The maximum instantaneous discharge on this day (July 15, 1929) is not available. This daily value is greater than all other instantaneous discharge values during the period of record.

Abbreviations: cms = cubic meters per second; cfs = cubic feet per second; ha-m = hectare-meter; ac-ft = acre-feet

The 1979 water quality data from the White River stations were compared to the earlier data (1975-1978) data by inspection. Statistical summaries and testing methods were not used because there was a limited amount of 1979 data for some flow periods, and the temporal spacing of sample collection in 1979 was not uniform. It was felt that these factors would cause a statistical analysis to produce misleading results.

The comparison of 1979 data to previous data indicates that there are some differences for several parameters. The March 30, 1979 sample during lower basin runoff was collected at a time when the instantaneous streamflow was 31.7 m^3/sec (1120 cfs). This streamflow value is considerably greater than the maximum instantaneous streamflow value corresponding to samples collected during lower basin runoff in previous years (24.2 m^3/sec [853 cfs]).

Several constituents for the March 30 sample had values which were greater than the maximum values for lower basin runoff during the previous years. These constituents included dissolved solids, sodium, Sodium Adsorption Ratio, percent sodium, sulfate and boron. The concentration of dissolved silica for this sample (6.6 mg/l) was less than the minimum value for lower basin runoff during the previous years (8.6 mg/l). These extreme values are probably related to the extreme value of instantaneous streamflow mentioned earlier. The proportion of the volume of lower basin surface runoff to the volume of the normal base flow would have been greater than for any previous samples. Surface water runoff from the lower basin typically has much higher levels of sodium, sulfate and boron than the water which makes up the

the baseflow of the White River. Therefore, it is logical that an increased proportion of runoff from the lower basin would cause increases in the concentrations of sodium, sulfate and boron, as well as the parameters associated with them.

The samples collected at station 6500 on May 24, 1979 and at station 6395 on June 5 and 6, 1979 corresponded to instantaneous streamflow values which were slightly greater than the maximum instantaneous streamflow value for upper basin runoff samples in the previous years (77.1 m^3/sec [2721 cfs]). The concentrations of dissolved manganese for the June 6, 1979 sample at stations 6395 and the concentrations of dissolved cadmium and dissolved lead for the June 5, 1979 sample at station 6395 were all greater than the maximum value for upper basin runoff samples during previous years. The dissolved silica value for the May 24, 1979 sample at station 6500 was less than the minimum value for upper basin runoff samples during previous years. It is probable that these extreme values are related to the extreme values of instantaneous streamflow when the samples were collected, and to physical and chemical mechanisms affecting solubility which occurred under those streamflow conditions.

The constituent values for the 1979 baseflow samples were all within the range of values for baseflow samples collected during previous years.

Only one of the extreme values for White River water quality during the 1979 water year was outside of the composite range of maximum and minimum values for all previously collected data during the Baseline and Interim periods. The dissolved silica value for the March 30

sample at station 6500 (6.6 mg/l) was lower than any of the values obtained during the previous four years of monitoring at the White River stations.

The differences in the physical and chemical composition of the White River between the 1979 water year and the previous years of record should be attributed to the hydrologic system's response to climatic variations. It is unlikely that the observed differences between periods represent a change in the White River hydrologic system. The analysis of data from all of the years of record helps to define the natural variations of streamflow and water quality.

Evacuation Creek

The flow regime during the 1979 water year was generally similar to the regime during the Baseline period (1975 and 1976 water years). Table 4.1-15 summarizes the streamflow records at station 6430 during each of the five years of the Baseline and Interim periods. This is the entire period of record for this station. The peak flow during 1979 (56.1 m^3/sec [1,980 cfs]) was considerably greater than the maximum from the previous four years (36.8 m^3/sec [1,300 cfs]). Also, the total annual runoff in 1979 (144 hectare-meters [1,170 acre-feet]) was slightly greater than the maximum from the previous four years (138 hectare-meters [1,120 acre-feet]).

The continuous record of water temperature at this station during 1979 was similar to previous years of record. The maximum instantaneous value during 1979 (34.0°C) was about the same as the maximum during the previous four years (33.5°C). The minimum instantaneous value during all five years has been 0.0°C.

TABLE 4.1-15

SUMMARY OF STREAMFLOW RECORDS
Evacuation Creek near Watson, Utah (Station 09306430)
Water Years 1975 - 1979

		1975 Water Year	1976 Water Year	1977 Water Year	1978 Water Year	1979 Water Year
Mean Daily Discharge	(cms)	0.032	0.044	0.019	0.017	0.046
	(cfs)	1.13	1.54	0.68	0.60	1.62
Maximum Daily Discharge	(cms)	1.76	2.49	2.12	1.87	1.67
	(cfs)	62	88	75	66	59
Maximum Instantaneous Discharge	(cms)	3.06	19.2	18.4	36.8	56.1
	(cfs)	108	679	648	1300	1980
Minimum Daily Discharge	(cms)	0.001	0.00	0.0003	0.00	0.0006
	(cfs)	0.03	0.00	0.01	0.00	0.02
Total Annual Runoff	(ha-m)	101	138	60.4	53.9	144
	(ac-ft)	817	1120	490	437	1170

Abbreviations: cms = cubic meters per second
cfs = cubic feet per second
ha-m = hectare-meter
ac-ft = acre-feet

The USGS has published continuous records of specific conductance at station 6430 for water years 1976 and 1977 and will publish the record for the 1979 water year. The maximum instantaneous value during 1979 (9,600 micromhos/cm) was greater than the previous maximum value (7,320 micromhos/cm). Also, the minimum instantaneous value during 1979 (90 micromhos/cm) was considerably less than the previous minimum value (559 micromhos/cm).

The USGS has published records of suspended sediment discharge at station 6430 for the 1977 and 1978 water years and will publish the 1979 record. The maximum daily suspended sediment discharge during each of these three years has been 35,700 tons, 33,000 tons, and 32,000 tons, respectively. The total annual discharges have been 89,052 tons, 56,264 tons, and 55,375 tons. For all three years, a large percentage of the annual total occurred on a single day, and was due to intense thunderstorm runoff.

The water quality data during 1979 were generally similar to the data collected during previous years of record at this station. However, the 1979 maximum values for several parameters exceeded the maximum values for the previously collected data. These parameters included:

Dissolved solids
Specific conductance
Magnesium
Sodium
Sodium Adsorption Ratio
Percent Sodium
Chloride
Sulfate
Fluoride
Nitrite plus Nitrate as N
Manganese

Also, some of the 1979 minimum values for water quality parameters were less than the minimum values for the previous years of record. These included:

Temperature
Chloride
Dissolved Oxygen
Copper

All other 1979 parameter values were within the range of values during the previous years of record.

The differences in streamflow and water quality between the 1979 water year and the earlier years of record at this station probably do not represent a change in the physical or chemical characteristics of this hydrologic system. It is more likely that these differences were caused by the hydrologic system's response to variations in climatic conditions. The data do not indicate that there have been any definite trends relating to changes in the physical and chemical composition of Evacuation Creek over the past five years. The analysis of data from all of the years of record helps to define the natural variations of streamflow and water quality.

Dry Washes

The streamflow records during the Baseline and Interim periods for the gaging stations at or near the mouths of Hell's Hole Canyon, Southam Canyon and Asphalt Wash are summarized in Tables 4.1-16, 4.1-17, and 4.1-18. The water years 1975 through 1979 are the entire period of record for these three stations. In Tables 4.1-16 and 4.1-17 it is noted that certain annual records were not complete. However, there was no evidence that any flow events occurred when these stations

TABLE 4.1-16

SUMMARY OF STREAMFLOW RECORDS
Hell's Hole Canyon Creek at Mouth, near Watson, Utah (Station 09306405)
Water Years 1975 - 1979

		1975 Water Year	1976 Water Year*	1977 Water Year	1978 Water Year	1979 Water Year
Mean Daily Discharge	(cms)	0.0028	0.00040	0.0020	0.0015	0.0021
	(cfs)	0.11	0.014	0.069	0.052	0.075
Maximum Daily Discharge	(cms)	0.42	0.017	0.20	0.31	0.23
	(cfs)	15	0.61	7.0	11	8.0
Maximum Instantaneous Discharge	(cms)	13.4	0.11	4.84	4.84	13.2
	(cfs)	473	3.8	171	171	467
Minimum Daily Discharge	(cms)	0.00	0.00	0.00	0.00	0.00
	(cfs)	0.00	0.00	0.00	0.00	0.00
Total Annual Runoff	(ha-m)	10	1.2	6.2	4.6	6.7
	(ac-ft)	83	10	50	37	54

*Note: Incomplete record for year.

Abbreviations: cms = cubic meters per second
cfs = cubic feet per second
ha-m = hectare-meter
ac-ft = acre-feet

TABLE 4.1-17

SUMMARY OF STREAMFLOW RECORDS
Southam Canyon Wash at Mouth, near Watson, Utah (Station 09306610)
Water Years 1975 - 1979

		1975 Water Year	1976 Water Year	1977 Water Year*	1978 Water Year*	1979 Water Year*
Mean Daily Discharge	(cms)	0.0016	0.00020	0.000048	0.000006	0.00042
	(cfs)	0.058	0.0070	0.0017	0.0002	0.015
Maximum Daily Discharge	(cms)	0.13	0.051	0.016	0.002	0.13
	(cfs)	4.7	1.8	0.57	0.07	4.7
Maximum Instantaneous Discharge	(cms)	0.85	0.74	0.74	0.12	11.1
	(cfs)	30	26	26	4.2	392
Minimum Daily Discharge	(cms)	0.00	0.00	0.00	0.00	0.00
	(cfs)	0.00	0.00	0.00	0.00	0.00
Total Annual Runoff	(ha-m)	5.2	0.63	0.15	0.017	1.4
	(ac-ft)	42	5.1	1.2	0.14	11

*Note: Incomplete record for year.

Abbreviations: cms = cubic meters per second
cfs = cubic feet per second
ha-m = hectare-meter
ac-ft = acre-feet

TABLE 4.1-18

SUMMARY OF STREAMFLOW RECORDS
Asphalt Wash near Mouth, near Watson, Utah (Station 09306625)
Water Years 1975 - 1979

		1975 Water Year	1976 Water Year	1977 Water Year	1978 Water Year	1979 Water Year
Mean Daily Discharge	(cms)	0.00071	0.0011	0.00034	0.00008	0.0054
	(cfs)	0.025	0.038	0.012	0.003	0.19
Maximum Daily Discharge	(cms)	0.13	0.12	0.088	0.019	0.45
	(cfs)	4.7	4.4	3.1	0.68	16
Maximum Instantaneous Discharge	(cms)	3.48	2.69	1.8	0.14	2.86
	(cfs)	123	95	65	4.8	101
Minimum Daily Discharge	(cms)	0.00	0.00	0.00	0.00	0.00
	(cfs)	0.00	0.00	0.00	0.00	0.00
Total Annual Runoff	(ha-m)	2.2	3.3	1.0	0.23	16.7
	(ac-ft)	18	27	8.4	1.9	135

Abbreviations: cms = cubic meters per second
cfs = cubic feet per second
ha-m = hectare-meter
ac-ft = acre-feet

were out of operation. Therefore, the data shown for those water years may be considered to be accurate annual values . These streamflow summaries for the dry washes illustrate a high degree of variation in peak discharges and total annual runoff from year to year.

The peak discharges at stations 6405, 6610, and 6625 for the five-year period of record are 13.4 m^3/sec (473 cfs), 11.1 m^3/sec (392 cfs), and 3.48 m^3/sec (123 cfs), respectively. These values were compared to Table II-5 of the First Year Environmental Baseline Report (FYEBR), but the results are inconclusive. (It should be noted here that Table II-5 of the FYEBR has two typing errors in it. These are: 1] the 5-year peak discharge by the SCS method for Hell's Hole Canyon should be 26 m^3/sec and 924 cfs; 2] the 10-year peak discharge by the SCS method for Hell's Hole Canyon should be 40 m^3/sec and 1400 cfs.) The unit peak discharges at stations 6405, 6610, and 6625 for the period of record are 0.211 $m^3/sec/km^2$ (19.3 cfs/mi^2), 0.516 $m^3/sec/km^2$ (47.2 cfs/mi^2), and 0.0138 $m^3/sec/km^2$ (1.26 cfs/mi^2). Additional analyses of flood frequency cannot be determined from the station records. This is because the five years of data available would be considered as insufficient for an accurate determination of flood frequency values up to the 100-year flood, according to standard USGS procedures.

The average annual runoff volumes for stations 6405, 6610 and 6625 for the five years of record are 5.8 hectare-meters (47 acre-feet), 1.5 hectare-meters (12 acre-feet), and 4.7 hectare-meters (38 acre-feet). These values were compared with Table II-3 of the FYEBR. The estimates presented in the FYEBR are considerably higher than the recorded values of runoff. The average values of unit runoff for the five years of

record at these stations are 0.091 centimeter (0.036 inch), 0.069 centimeter (0.027 inch), and 0.019 centimeter (0.0073 inch). This indicates that the volume of surface runoff leaving the three dry wash drainages averaged less than 0.5% of the volume of precipitation falling on these drainages over the 1975 through 1979 water years. The variations in unit runoff between the three dry wash drainages are probably somewhat misleading because of the short period of record. Trends established from short periods of record tend to weight extreme values out of proportion to average values. It is very likely that over a longer period of record (at least ten years) the variations in unit runoff between the dry wash drainages would be reduced, because the areal distribution of climatic variations would be more homogeneous.

The water quality data collected during the 1979 water year at stations 6405, 6610 and 6625 illustrate wide variations. This situation also occurred during the Baseline period (1975 and 1976 water years). The variations between samples collected at different times at each station are related to variations of streamflow conditions at that station. This was discussed in more detail in the Final Environmental Baseline Report (FEBR). Because of the wide variation of water quality at each station, it is not meaningful to make a comparison between years. The combination of the entire data record at each station over several years should help to characterize the water quality of that drainage since hydrologic events, and therefore water quality, vary considerably from year to year.

Certain observations can be made based on a comparison of the water quality data between stations 6405, 6610, and 6625. The most noticeable differences are in the distribution of major ions. Samples collected at station 6405 in Hell's Hole Canyon have higher relative proportions of calcium and magnesium (therefore, lower values of Sodium Adsorption Ratio and percent sodium) than the samples collected at station 6610 in Southam Canyon and station 6625 in Asphalt Wash. Also, the 1979 sample at station 6405 illustrated a much higher relative proportion of bicarbonate than the 1979 samples at the other two stations. These differences in water quality are probably related to the differences in streambed minerology, which were presented in the FEBR. Streambed samples at station 6405 illustrated a much lower percentage of feldspar and a much higher percentage of dolomite in comparison to the streambed samples collected at stations 6610 and 6625.

In summary, no conclusions can be drawn concerning the differences in streamflow and water quality of the dry washes between the 1979 water year and the previous years of record. This is because the data collected during each year, and even during each flow event, will illustrate wide variations due to natural causes. It is necessary to combine several years of data in order to adequately characterize the physical and chemical composition of surface water in the dry washes.

4.1.2 Bedrock Aquifer Water

The aquifers being monitored at the project area are divided into two groups: the bedrock aquifer water and the alluvial aquifer water.

The term, "bedrock aquifer water," refers to ground water contained within the Uinta and Green River Formations. The principle aquifers in the project area are the Bird's Nest aquifer located in the upper portion of the Parachute Creek Member, and the Douglas Creek aquifer located in the Douglas Creek Member. Both of these members belong to the Green River Formation. These two aquifers are separated by impermeable strata of the Parachute Creek and Garden Gulch Members of the Green River Formation.

All bedrock aquifer wells, with the exception of P-2 Upper and P-4, are monitoring the Bird's Nest aquifer. Well P-2 Upper monitors an aquifer of limited areal extent located in a zone near the contact of the Uinta and Green River Formations, and is referred to as the Upper aquifer. Well P-4 is probably receiving water from both the Bird's Nest and the Douglas Creek aquifers. This well was originally drilled into the Douglas Creek Member and grouted back to the Bird's Nest aquifer. Water levels are indicative of the Douglas Creek aquifer; therefore, an imperfect grout seal is probably allowing upward leakage.

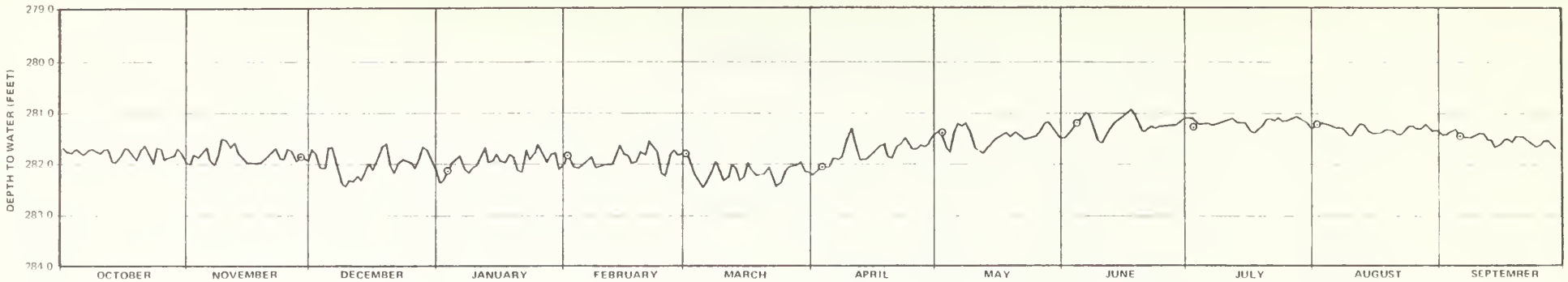
The bedrock aquifer water monitoring program involved only WRSP efforts. The continuous monitoring of static water levels of wells P-1, P-2 Upper and P-2 Lower was taken over from the USGS on November 28, 1978.

4.1.2.1 Objectives. The objectives of this monitoring element are to extend water level data so as to provide continuity between the Baseline study and future monitoring periods, and to investigate long-term water level trends.

4.1.2.2 Methods. Water levels were continuously monitored through the year by WRSP at wells P-1, P-2 Upper, P-2 Lower and P-3. Time activated digital punch recorders recorded the water level every hour at these four wells. For quality assurance, WRSP manually checked the water level at all four wells once per month.

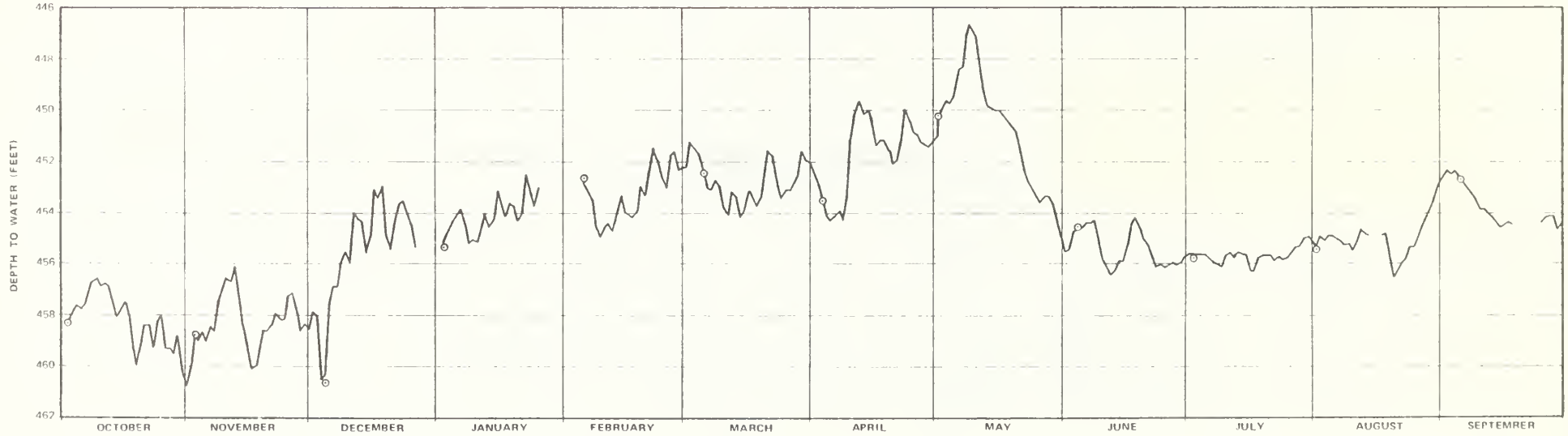
Manual water level readings were taken by WRSP at G-5, G-8, G-8A, G-10, G-11, G-15, G-21 and P-4 in November 1978 and April 1979, which correspond to maximum and minimum water levels, respectively, as found during the Baseline period.

4.1.2.3 Data Summary. The continuous hydrographs for wells P-1, P-2 Upper, P-2 Lower, and P-3 are shown in Figures 4.1-15 and 4.1-16. Semi-annual static water level measurements for the other deep wells are shown in Table 4.1-19. The data indicate that the static water levels of wells P-1, P-2 Upper and P-2 Lower remained steady throughout the year. The static water level of well P-3 continued to remain relatively stable during October and November 1978 as it had during May through September 1978. From early December 1978 to May 9, 1979 water levels continued to rise to a height of 136.2 meters (446.7 feet). In October 1976, the beginning of the Interim period, the static water level of well P-3 was 148.7 meters (488 feet). This represents a rise in static water level of 12.6 meters (41.3 feet) in 31 months. Water level measurements declined 2.7 meters (8.9 feet) from May 9 to June 1 and were relatively stable for the period June 1 to September 30, 1979. The general configuration of the water level contours in April 1979 for Bird's Nest aquifer is shown on Figure



NOTE ⊙ ARE MANUAL MEASUREMENTS BY ELECTRIC PROBE
ALL MEASUREMENTS FROM APPROXIMATE TOP OF WELL COLLAR
GROUND SURFACE ELEVATION = 5284
MEASURING POINT ELEVATION = 5286.9

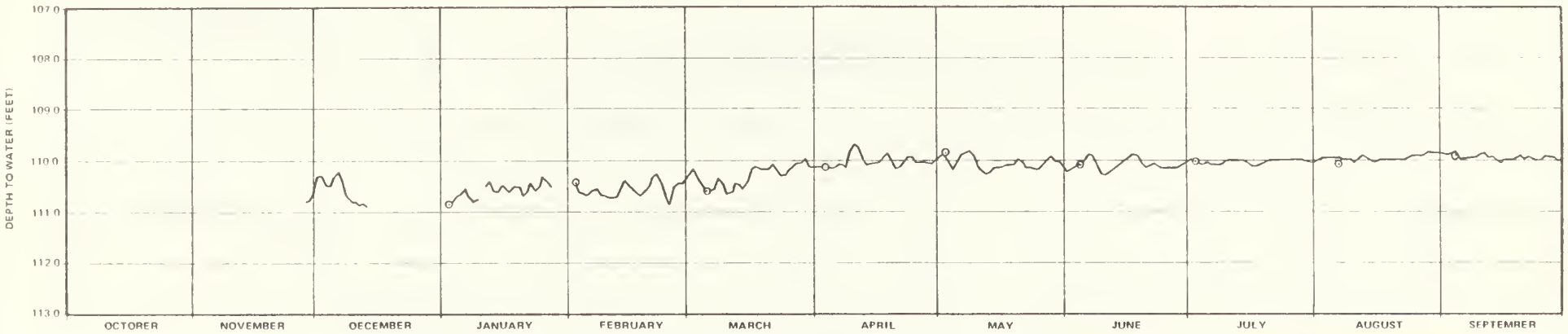
CONTINUOUS STATIC WATER LEVEL MEASUREMENTS
MONITOR WELL P-1
OCTOBER 1978 – SEPTEMBER 1979



CONTINUOUS STATIC WATER LEVEL MEASUREMENTS
MONITOR WELL P-3
OCTOBER 1978 – SEPTEMBER 1979

NOTE ⊙ ARE MANUAL MEASUREMENTS BY ELECTRIC PROBE
ALL MEASUREMENTS FROM APPROXIMATE TOP OF WELL COLLAR
GROUND SURFACE ELEVATION = 5486.0
MEASURING POINT ELEVATION =

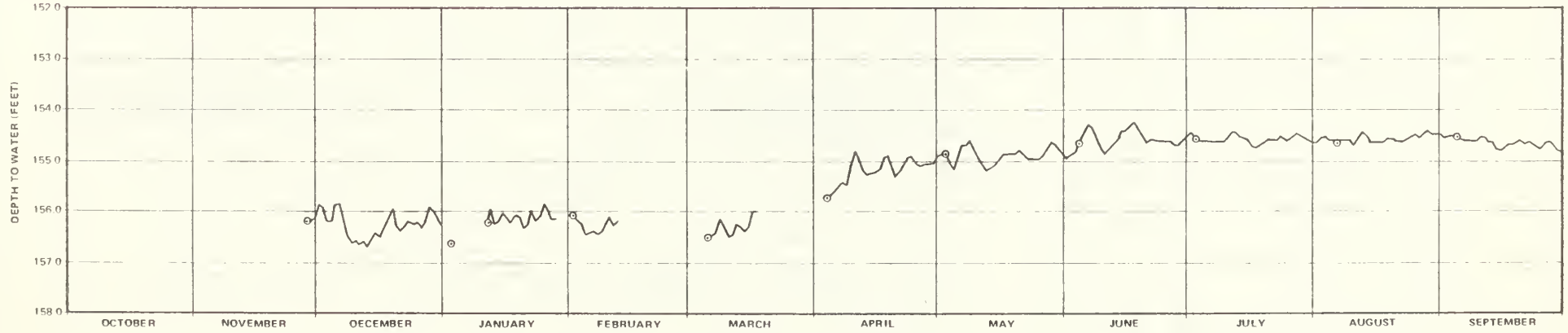
FIGURE 4.1-15



CONTINUOUS STATIC WATER LEVEL MEASUREMENTS
MONITOR WELL P-2 UPPER
OCTOBER 1978 – SEPTEMBER 1979

NOTE ⊙ ARE MANUAL MEASUREMENTS BY ELECTRIC PROBE
ALL MEASUREMENTS FROM APPROXIMATE TOP OF WELL COLLAR
GROUNO SURFACE ELEVATION = 4991
MEASURING POINT ELEVATION = 4994 5

Note: P-2 Upper - All readings on above graph should be minus 10 ft. for entire year.



CONTINUOUS STATIC WATER LEVEL MEASUREMENTS
MONITOR WELL P-2 LOWER
OCTOBER 1978 – SEPTEMBER 1979

NOTE ⊙ ALL MANUAL MEASUREMENTS BY ELECTRIC PROBE
ALL MEASUREMENTS FROM APPROXIMATE TOP OF WELL COLLAR
GROUNO SURFACE ELEVATION = 4991
MEASURING POINT ELEVATION = 4994.5

FIGURE 4.1-16

TABLE 4.1-19

SEMI-ANNUAL WATER LEVEL MEASUREMENTS
FOR DEEP AQUIFER WELLS

October 1978-September 1979

Well Number	Total Depth (feet)	Approx. Ground Surface Elevation (feet)	Static Water Level Depth (feet)	Static Water Level Approx. Elev. (feet)	Date Measured
G-5	620	5,292.0	459.7	4,832.3	11/14/78
			458.6	4,833.4	4/23/79
G-8	127	5,095.5	54.0	5,041.5	11/14/78
			53.0	5,042.5	4/23/79
G-8A	100	5,095.0	42.5	5,052.5	11/14/78
			41.7	5,053.3	4/23/79
G-10	400	5,364.0	317.2	5,046.8	11/14/78
			308.8	5,055.2	4/23/79
G-11	650	5,375.0	469.9	4,905.1	11/14/78
			468.3	4,906.7	4/23/79
G-15	627	5,343.0	509.2	4,833.8	11/14/78
			507.7	4,835.3	4/23/79
G-21	611	5,262.0	429.8	4,832.3	11/14/78
			426.9	4,835.1	4/23/79
P-4	400	5,718.5	266.2	5,452.3	11/14/78
			265.7	5,452.8	4/23/79

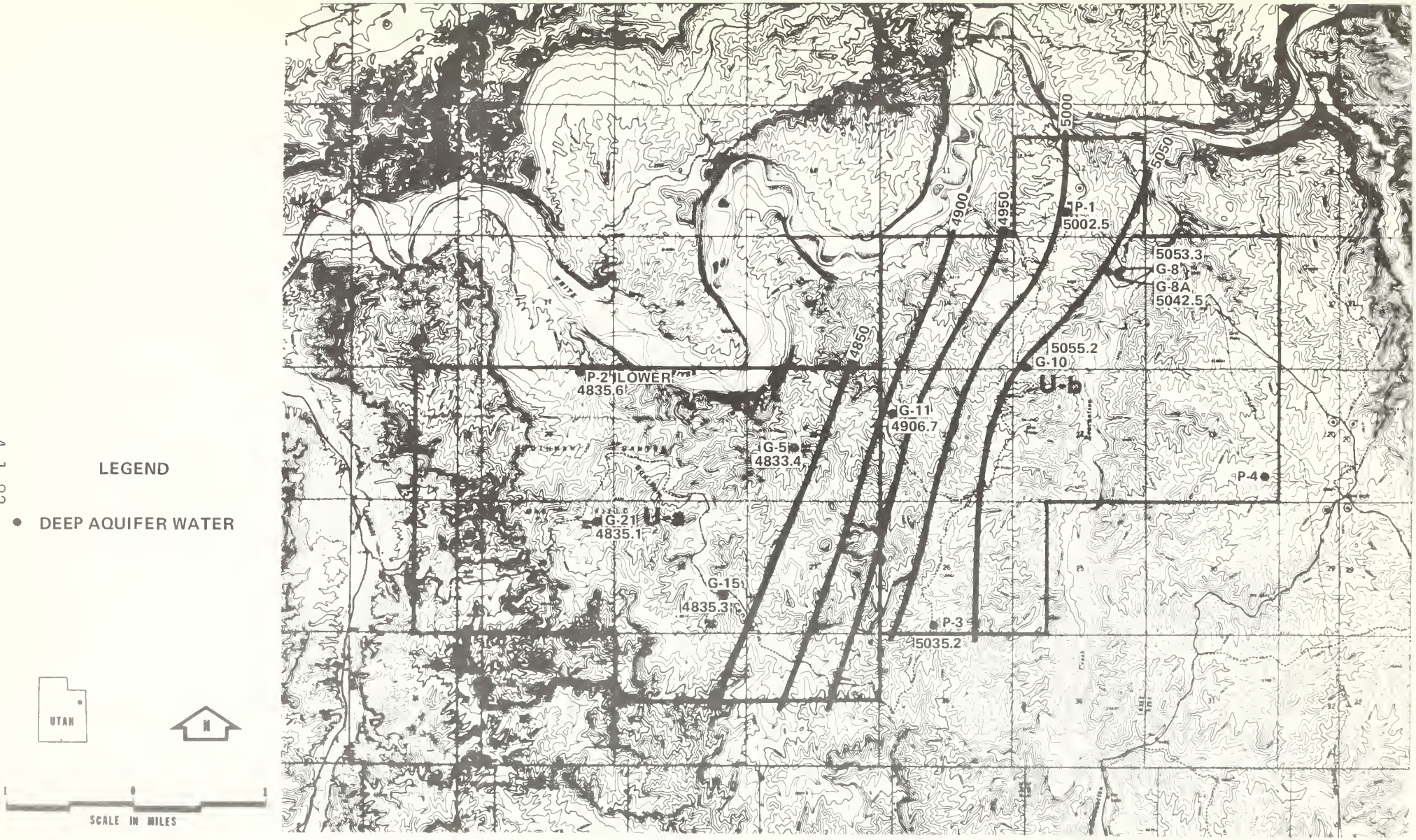
Note: All measurements were taken manually with electric probe.

4.1-17. The direction of ground water flow based on the static water level measurements from the monitor wells completed into the Bird's Nest aquifer is towards the northwest. The configuration of the water level contours map indicates the same ground water conditions exist for the Bird's Nest aquifer as during the measurements taken in March 1975 (illustrated in the FYEBR).

4.1.2.4 Conclusions. The static water levels of bedrock aquifer monitoring wells during the 1979 water year have remained at levels similar to those found during the Baseline period, in all three aquifers (Upper, Bird's Nest and Douglas Creek), with one exception at well P-3.

Previous studies indicated a very high percent of barometric efficiency for the continuously monitored wells P-1, P-2 Upper, P-2 Lower and P-3. Fluctuations in static water levels in all monitor wells, with the exception of P-3, have been small and are probably the result of seasonal influences and changes in barometric pressure.

Static water levels in P-3 have continued to rise at a relatively consistent rate. Probable explanations for this slow rise in static water level are: slow recharge to the aquifer from upward leakage through the grout seal of well P-3, and/or upward leakage through the grout seal of wells in the immediate area which penetrate the Douglas Creek Member. The rise and decline of static water levels of several feet within a week or less in well P-3 may be a result of: variation of barometric pressure, and/or variations in the rate of emission of hydrogen sulphide gas.



CONTOUR MAP OF THE PIEZOMETRIC SURFACE OF THE BIRD'S NEST AQUIFER

APRIL 1979

FIGURE 4.1-17

4.1.3 Alluvial Aquifer Water

The alluvial aquifer water monitoring program involved only WRSP efforts. The monitoring program conducted by the USGS during previous years was taken over by WRSP on October 1, 1978. Alluvial wells AG-1-1 (lower) and AG-1-2 (upper) were deleted from the 1979 program for the following reasons: 1) well AG-1-2 would not produce adequate water for sampling, 2) both of the wells would be inundated by the proposed White River reservoir. Also, the alluvial wells in upper Evacuation Creek (near Park Canyon and above Missouri Creek), well AG-4 in Asphalt Wash, and the wells in Hell's Hole Canyon were not included in the 1979 monitoring program. These wells are outside of the boundaries of the tracts and the key areas of interest.

4.1.3.1 Objectives. The objectives of the program are to extend the data base in regard to alluvial well water levels and water quality so as to provide continuity between the monitoring program to date and the future monitoring periods, and to investigate long-term trends of water level and water quality.

4.1.3.2 Methods. Monthly measurements of static water level, temperature and specific conductance were made at five wells in three drainage areas:

1. White River: AG-3-1 (lower) and AG-3-3 (upper)
2. Evacuation Creek: AG-8
3. Southam Canyon: AG-6-1 (lower) and AG-6-2 (upper)

All of the wells were inaccessable in February 1979 due to deep snow cover. The work plan for the 1979 water year called for a water

quality sample to be collected from all five wells in September 1979. Samples were collected at all wells except for AG-8. This well would not produce enough water for a sample, and had apparently silted in to within less than a foot of the water surface in the well. The 1979 work plan also called for a water quality sample to be collected from a well if the specific conductance reading was 20% greater than the maximum recorded value or 20% less than the minimum recorded value of specific conductance for previously collected laboratory water quality samples from that well. The specific conductance values for wells AG-6-1 and AG-6-2 in January were less than the minimum criteria described above. WRSP decided not to collect samples at these two wells before September 1979, because the decreases in these specific conductance values were the continuation of the trend from previous years of record at these wells. It was felt that the September samples at the end of the water year would describe the state of water quality for these wells adequately. Also, it was felt that the water quality trend could be established by relating the monthly specific conductance measurements during the year to water quality data from samples collected at both wells in May 1978 and in September 1979.

On September 26, 1979 flash floods in Southam Canyon and Evacuation Creek destroyed wells AG-6-2 and AG-8.

4.1.3.3 Data Summary

Static Water Levels

The monthly measurements of the static water level of the five alluvial wells are shown in Table 4.1-20. The depth to the static water level (SWL) was measured from the top of the well casing.

TABLE 4.1-20

ALLUVIAL WELL MEASUREMENTS
WHITE RIVER, EVACUATION CREEK, AND DRY WASH ALLUVIUM
October 1978 - September 1979

		October	November	December	January	February	March	April	May	June	July	August	September
AG-3-1													
	Date			4	10		5	4	8	14	9	23	21
	SWL			13.10	12.20		12.53	12.15	11.83	10.12	11.33	12.56	13.57
	T			7.0	7.0		9.0	10.0	8.0	14.0	12.5	14.5	13.5
	SC			4,400	4,100		3,500	3,700	3,900	3,500	3,800	3,700	3,700
AG-3-3													
	Date			4	10		5	4	8	14	9	23	21
	SWL			12.83	11.95		11.10	11.70	11.42	9.82	11.00	12.30	12.93
	T			6.5	7.0		9.0	11.0	8.0	15.0	14.5	14.5	14.0
	SC			3,200	3,500		3,000	3,000	4,200	3,000	3,200	3,000	3,000
AG-8													
	Date			7	3		5	5	8	12	10	21	24
	SWL			Frozen	Frozen		Frozen	3.72	4.85	4.95	5.13	4.55	5.65
	T							9.0	9.0	17.0	20.5	19.0	15.5
	SC							2,000	7,000	6,000	6,000	4,600	5,800
AG-6-1													
	Date		2	4	25		5	3	8	12	9	21	21
	SWL		17.73	17.74	17.50		17.58	18.00	18.10	16.55	16.50	17.60	18.00
	T		11.5	6.5	12.0		12.0	14.0	11.5	13.0	14.0	14.0	14.5
	SC		1,900	1,850	1,300		1,425	1,300	1,350	1,300	1,390	1,300	1,650
AG-6-2													
	Date		2	4	25		5	3	8	12	9	21	21
	SWL		19.08	18.40	18.20		16.30	16.68	16.80	15.30	17.40	18.86	19.30
	T		11.5	7.5	12.0		11.0	14.0	10.5	14.0	14.0	14.0	14.0
	SC		1,550	1,525	1,300		1,150	1,325	1,600	1,500	1,300	1,290	1,260

Note: Static Water Level (SWL) is the depth to water in feet from the top of the well casing; Temperature (T) is in °C; Specific Conductance (SC) is in micromhos/cm.

Alluvial wells AG-3-1 and AG-3-3 in the White River alluvium illustrated water level fluctuations of 1.05 meters (3.45 feet) and 0.95 meter (3.11 feet), respectively. The static water level of both wells was highest in June and lowest in September, which corresponds to the peak flow and low flow periods of the White River.

Well AG-8 in the Evacuation Creek alluvium was frozen in the winter and had a water level fluctuation of 0.59 meter (1.93 feet) during the rest of the year. The static water level was highest in April and lowest in September, which also corresponded with the peak flow and low flow periods of Evacuation Creek.

Alluvial wells AG-6-1 and AG-6-2 in the Southam Canyon alluvium illustrated water level fluctuations of 0.49 meter (1.60 feet) and 1.22 meters (4.00 feet) during the year. Visual inspection of the data (see Table 4.1-20) suggests that the values for these two wells have been transposed for the months of March, April, May, and June. The field data notebooks were rechecked and no errors were found in recording or transcribing of the data. Therefore, it was assumed that the values are correct as shown in the table. The highest water levels occurred in July at AG-6-1 and in June at AG-6-2; the lowest water levels occurred in May at AG-6-1 and in September at AG-6-2.

Water Quality

The monthly field measurements of temperature and specific conductance for the five alluvial wells are shown in Table 4.1-20. The laboratory analyses for the water quality samples collected on September 21 from wells AG-3-1, AG-3-3, AG-6-1, and AG-6-2 are shown in Table 4.1-21.

TABLE 4.1-21

SUMMARY OF ALLUVIAL WATER QUALITY
October 1978 - September 1979

		AG-3-1 Sept. 21, 1979	AG-3-3 Sept. 21, 1979	AG-6-1 Sept. 21, 1979	AG-6-2 Sept. 21, 1979
GENERAL CHARACTERISTICS					
Total Alkalinity as $CaCO_3$	(mg/l)	480	490	320	320
Dissolved Solids, calc. sum	(mg/l)	3,210	2,460	1,200	924
Total Hardness as $CaCO_3$	(mg/l)	1,200	870	320	250
Noncarbonate Hardness as $CaCO_3$	(mg/l)	760	380	4	0
pH	(units)	8.0	8.0	8.2	8.2
Specific Conductance at 25°C	(umhos/cm)	3,700	3,000	1,650	1,260
Temperature	(°C)	13.5	14.0	14.5	14.0
MAJOR CATIONS					
Calcium, dissolved	(mg/l)	200	150	70	50
Magnesium, dissolved	(mg/l)	180	120	36	31
Potassium, dissolved	(mg/l)	4.7	4.9	2.8	2.9
Sodium, dissolved	(mg/l)	550	450	260	210
Sodium Adsorption Ratio		6.8	6.6	6.3	5.8
Percent Sodium		70	53	76	64
Strontium, dissolved	(ug/l)	3,200	2,000	1,200	1,200
MAJOR ANIONS					
Chloride, dissolved	(mg/l)	150	110	45	41
Sulfate, dissolved	(mg/l)	1,800	1,300	570	370
Sulfide as S, total	(mg/l)	2.2	0.4	0.0	3.2
Bromide, dissolved	(mg/l)	0.5	1.2	0.4	1.2
Fluoride, dissolved	(mg/l)	1.1	0.5	0.2	0.2
BIOCHEMICAL CONSTITUENTS					
Chemical Oxygen Demand	(mg/l)	--	610	--	640
Organic Carbon, dissolved	(mg/l)	41	43	7.3	6.4

TABLE 4.1-21 (cont.)

SUMMARY OF ALLUVIAL WATER QUALITY
October 1978 - September 1979

		AG-3-1 Sept. 21, 1979	AG-3-3 Sept. 21, 1979	AG-6-1 Sept. 21, 1979	AG-6-2 Sept. 21, 1979
MACRONUTRIENTS					
Ammonia as N, dissolved	(mg/l)	0.48	0.57	0.06	0.00
Nitrite plus Nitrate as N, dissolved	(mg/l)	0.04	0.06	0.06	0.17
Ammonia plus Organic Nitrogen as N, total	(mg/l)	2.5	6.6	0.84	2.8
Total Phosphorus as P	(mg/l)	0.29	3.7	0.59	3.7
Ortho-Phosphorus as P, dissolved	(mg/l)	0.03	0.05	0.07	0.02
MICRONUTRIENTS					
Boron, dissolved	(ug/l)	4,800	4,700	260	230
Copper, dissolved	(ug/l)	0	30	33	14
Iron, dissolved	(ug/l)	60	110	70	360
Manganese, dissolved	(ug/l)	460	290	290	210
Zinc, dissolved	(ug/l)	8,000	80	340	190
Molybdenum, dissolved	(ug/l)	20	16	12	16
Silica as SiO_2, dissolved	(mg/l)	19	19	20	22
TRACE METALS					
Aluminum, dissolved	(ug/l)	40	20	30	140
Barium, dissolved	(ug/l)	200	200	30	80
Cadmium, dissolved	(ug/l)	0	0	1	<1
Chromium, dissolved	(ug/l)	10	10	10	10
Lead, dissolved	(ug/l)	0	0	<10	<10
Lithium, dissolved	(ug/l)	120	100	20	10
Mercury, dissolved	(ug/l)	0.0	0.0	0.0	0.1
Selenium, dissolved	(ug/l)	0	0	2	2
Vanadium, dissolved	(ug/l)	1	1	3	11
TRACE NON-METALS					
Arsenic, dissolved	(ug/l)	2	6	3	4
Phenols	(ug/l)	5	4	5	4

At well AG-3-1, the monthly temperature values ranged from 7.0°C to 14.5°C. The specific conductance values ranged from 3500 micromhos/cm to 4400 micromhos/cm. When the water quality sample was collected on September 21, the specific conductance was 3700 micromhos/cm and the dissolved solids concentration was 3210 mg/l. At well AG-3-3, the monthly temperature values ranged from 6.5°C to 15.0°C. Specific conductance values varied from 3000 micromhos/cm to 4200 micromhos/cm. The specific conductance and dissolved solids values were 3000 micromhos/cm and 2460 mg/l, respectively, for the September 21 sample from this well.

The water temperatures for well AG-8 varied from 0.0°C (frozen) to 20.5°C. The specific conductance values had a range of 2000 micromhos/cm to 7000 micromhos/cm.

At well AG-6-1, the water temperatures ranged from 6.5°C to 14.5°C, and specific conductance ranged from 1300 micromhos/cm to 1900 micromhos/ cm. The water quality sample collected on September 21 had a specific conductance of 1650 micromhos/cm and a dissolved solids concentration of 1200 mg/l. At well AG-6-2, the water temperatures ranged from 7.5°C to 14.0°C, while the specific conductance ranged from 1150 micromhos/cm to 1600 micromhos/cm. The values of specific conductance and dissolved solids for the September 21 sample were 1260 micromhos/cm and 924 mg/l, respectively.

4.1.3.4 Conclusions. The 1979 work plan involved two major areas of interest regarding the alluvial aquifer water. These are: 1) the the comparison of water level and chemical composition between the data

collected during the 1979 water year and the data collected during earlier monitoring periods; 2) the comparison of chemical composition between the upper and lower well points at any specific location.

Comparison of Water Level and Chemical Composition Between the 1979 Water Year and Previous Years (1976-1978)

The water level fluctuations were generally similar to the fluctuations during earlier years of record. Well AG-6-2 did exhibit a slightly greater range of water level fluctuation compared to previous years. The lowest water level for this well was similar to previous years, but the highest water level was 0.50 meter (1.65 feet) greater than the highest water level during previous years.

The water quality of the alluvial aquifers at wells AG-3-1, AG-3-3, and AG-8 was generally similar to the water quality during earlier years of record. The baseline description of these wells was given in the 1977 Annual Report and the 1977 Supplemental Report. There were a few data values from the September 1979 water quality analyses which were notably greater than the maximum values from the Baseline period. These included: 1) dissolved zinc for well AG-3-1 (8000 ug/l vs. 860 ug/l); 2) dissolved organic carbon for well AG-3-1 (41 mg/l vs. 4.9 mg/l); and 3) chemical oxygen demand for well AG-3-3 (610 mg/l vs. 76 mg/l). These constituents were analyzed only once during the Baseline period, so these comparisons are not conclusive.

The water quality of wells AG-6-1 and AG-6-2 in Southam Canyon during the 1979 water year was generally improved (in regard to dissolved solids content) as compared to the earlier years of record. The specific conductance values and dissolved solids concentrations

for the September 1979 water quality analyses at these two wells were considerably less than the minimum values from the May 1978 water quality analyses and the analyses during the Baseline period. At well AG-6-1, the dissolved solids concentration had decreased from 1810 mg/l in May 1978 to 1200 mg/l in September 1979; at well AG-6-2, the dissolved solids concentration had decreased from 1250 mg/l in May 1978 to 924 mg/l in September 1979. Several other constituents have also illustrated notable decreases in time. These include: calcium, magnesium, potassium, sodium, sulfate, strontium, nitrite plus nitrate, manganese, zinc, chromium, and selenium. The concentration of dissolved organic carbon for well AG-6-1 was somewhat higher for the September 1979 sample analysis than the maximum value for analyses during the Baseline period (41 mg/l vs. 11 mg/l). Inspection of the field values of specific conductance during the period of record for these two wells suggests that the alluvial water quality has been relatively stable at the AG-6 location since August 1978.

Comparison of Chemical Composition Between Upper and Lower Wells

The relationship between the upper and lower wells at the AG-3 location (AG-3-3 and AG-3-1, respectively) during the 1979 water year was similar to the relationship during previous years; i.e., the dissolved solids concentration was somewhat less for the upper well than the lower well (2460 mg/l vs. 3210 mg/l). This relationship has been discussed in detail in the 1977 reports mentioned earlier.

At the AG-6 location, the dissolved solids concentration for the upper well, AG-6-2, was also somewhat less than for the lower

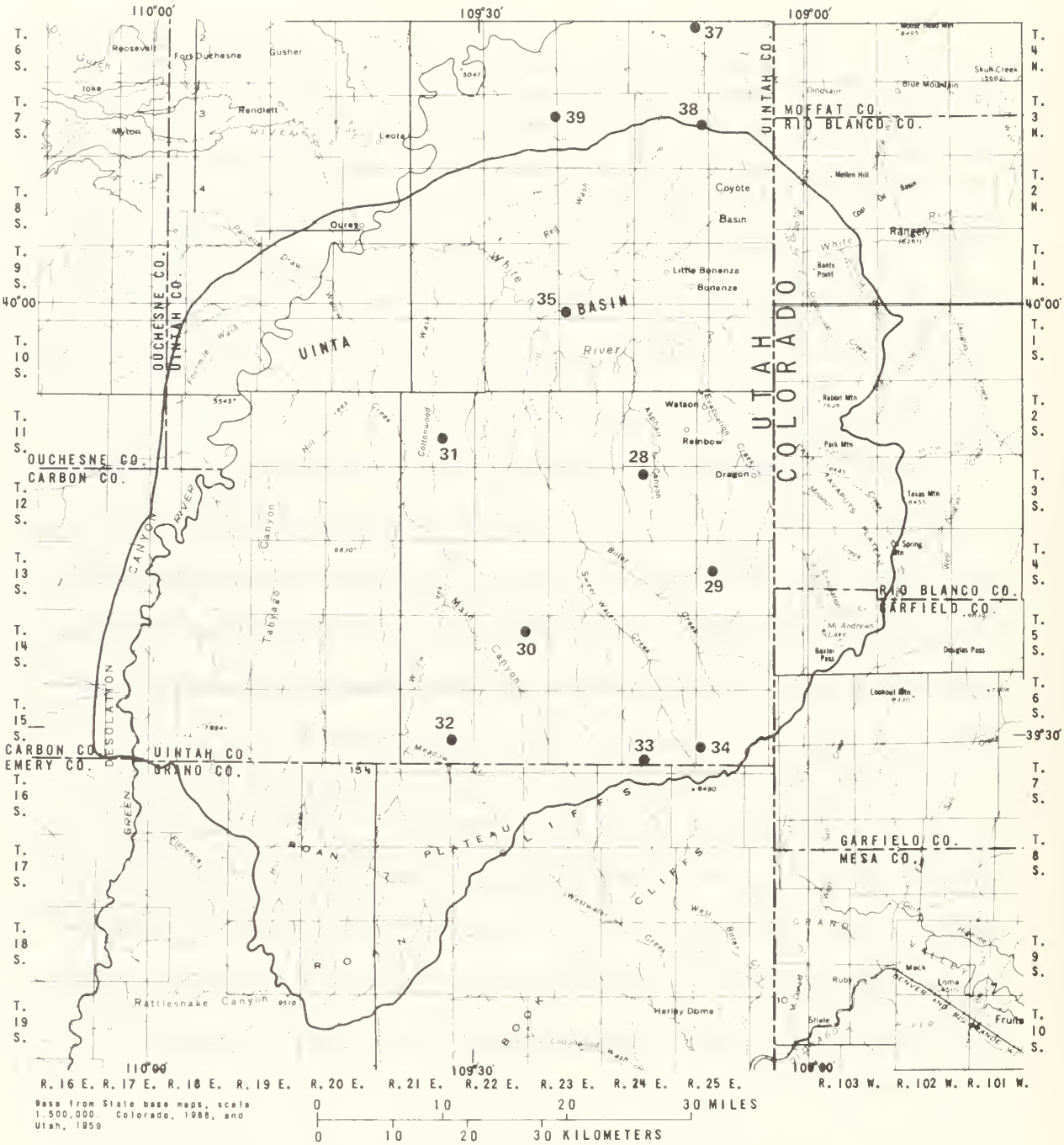
well, AG-6-1 (924 mg/l vs. 1200 mg/l). As would be expected, the concentrations of several of the major ions were also less for the upper well than the lower well. In contrast, some of the nutrients and trace materials were present in notably greater concentrations in the upper well. These include: sulfide, ammonia plus organic nitrogen, total phosphorus, iron, aluminum, and vanadium.

4.1.4 Precipitation/Evaporation

This element of the water resources monitoring program involved a combination of efforts by the Bureau of Land Management (BLM) and WRSP. During the 1979 water year the BLM monitored a regional network of precipitation gauges in the Uinta basin in the vicinity of Tracts Ua/Ub, while WRSP monitored a site specific network of precipitation gauges and evaporation pans located on Tracts Ua/Ub.

4.1.4.1 Objectives. The objectives of the WRSP precipitation/evaporation program are to augment the BLM regional data collection network, shown in Figure 4.1-18, to provide the site specific information on precipitation and evaporation at the plant site and processed shale disposal area, and to place the Interim period in historic perspective.

4.1.4.2 Methods. Precipitation was measured by automatic gauges at three locations. The gauge at the plant site (ARA-13) was operated year round. The other two automatic gauges in Southam Canyon (ARA-2 and ARS-9) were in operation during October 1978 and from April 1, 1979 through September 30, 1979. Precipitation was measured by standard



NOTE:

GAUGE NUMBER 36 IS LOCATED IN SECTION 24, T5S, R25E.
GAUGE NUMBER 40 IS LOCATED IN SECTION 30, T5S, R25E.

LEGEND

● **PRECIPITATION GAUGE**

BLM REGIONAL PRECIPITATION NETWORK

FIGURE 4.1-18

storage gauges at the three automatic gauge locations (as a back up in case of breakdowns), as well as at the mouth of Southam Canyon (RS-13), at the A-4 air station located between Southam Canyon and Evacuation Creek (RA-4), and near the mouth of Asphalt Wash (RS-11). These gauges were maintained throughout the year. Also, the annual precipitation records from two storage gauges involved in the revegetation study for Tracts Ua/Ub were obtained. These are located near the A-7 air station north of the White River (RV-7) and near well G-8 in the Evacuation Creek drainage (RV-8).

Evaporation from ground pans was measured in Southam Canyon (EVP-2) and at the plant site (EVP-13) during the freeze-free period. The records for these two sites began May 1, 1979 and ended on September 27, 1979.

4.1.4.3 Data Summary

Precipitation

Monthly precipitation data for the WRSP gauges are shown in Table 4.1-22. Seasonal and annual precipitation data are shown in Table 4.1-23. The spatial variations of annual and seasonal precipitation on the tracts are shown in Figures 4.1-19 through 4.1-23. Annual precipitation varied from a maximum of 32.74 cm (12.89 inches) at RA-4 to a minimum of 24.97 cm (9.83 inches) at RS-13, and averaged 27.40 cm (10.79 inches) for all of the gauge locations.

Fall and winter were the periods of maximum precipitation for the area, with 7.32 cm (2.88 inches) and 8.79 cm (3.46 inches), respectively; spring precipitation was 5.56 cm (2.19 inches); and summer

TABLE 4.1-22

MONTHLY PRECIPITATION RECORDS
October 1978 - September 1979

Station	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual Total
ARA-2	0.50	1.47*	0.94*	1.20*	0.05*	2.35*	0.90	1.20	0.20	0.20	0.80	0.10	9.91 in.
	(1.27)	(3.73*)	(2.39*)	(3.05*)	(0.13*)	(5.97*)	(2.29)	(3.05)	(0.51)	(0.51)	(2.03)	(0.25)	(25.17 cm.)
RA-4	0.45	1.49	1.04	1.05	0.10	2.38	0.85	1.47	0.00	0.61	1.12	2.33	12.89 in.
	(1.14)	(3.78)	(2.64)	(2.67)	(0.25)	(6.05)	(2.16)	(3.73)	(0.00)	(1.55)	(2.84)	(5.92)	(32.74 cm.)
ARS-9	0.50	1.44*	1.06*	1.19*	0.00*	1.80*	0.90	1.40	0.10	0.60	0.90	1.40	11.29 in.
	(1.27)	(3.66*)	(2.69*)	(3.02*)	(0.00*)	(4.57*)	(2.29)	(3.56)	(0.25)	(1.52)	(2.29)	(3.56)	(28.68 cm.)
ARA-13	0.50	1.20	0.70	0.80	0.20	2.60	0.70	1.40	0.10	0.90	0.93*	0.30	10.33 in.
	(1.27)	(3.05)	(1.78)	(2.03)	(0.51)	(6.60)	(1.78)	(3.56)	(0.25)	(2.29)	(2.36*)	(0.76)	(26.24 cm.)
RS-13	0.53	1.37	1.00	1.05	0.00	1.50	0.97	1.21	T	0.51	1.60	0.09	9.83 in.
	(1.35)	(3.48)	(2.54)	(2.67)	(0.00)	(3.81)	(2.46)	(3.07)	(T)	(1.30)	(4.06)	(0.23)	(24.97 cm.)
RV-7	0.59	1.11	1.27	0.45	0.25	2.65	0.95	1.33	T	0.69	0.76	0.25	10.30 in.
	(1.50)	(2.82)	(3.23)	(1.14)	(0.64)	(6.73)	(2.41)	(3.38)	(T)	(1.75)	(1.93)	(0.64)	(26.16 cm.)
RV-8	0.60	1.19	0.87	0.85	0.00	2.76	0.73	1.58	0.00	1.28	0.76	0.55	11.17 in.
	(1.52)	(3.02)	(2.21)	(2.16)	(0.00)	(7.01)	(1.85)	(4.01)	(0.00)	(3.25)	(1.93)	(1.40)	(28.37 cm.)
RS-11	0.47	1.50	1.22	0.83	0.05	3.58	0.95	0.50	0.00	0.64	0.56	0.19	10.57 in.
	(1.19)	(3.81)	(3.10)	(2.11)	(0.13)	(9.09)	(2.41)	(1.27)	(0.00)	(1.63)	(1.42)	(0.48)	(26.85 cm.)

Note: The designation, "T," stands for trace amount.

*From backup gauge.

TABLE 4.1-23

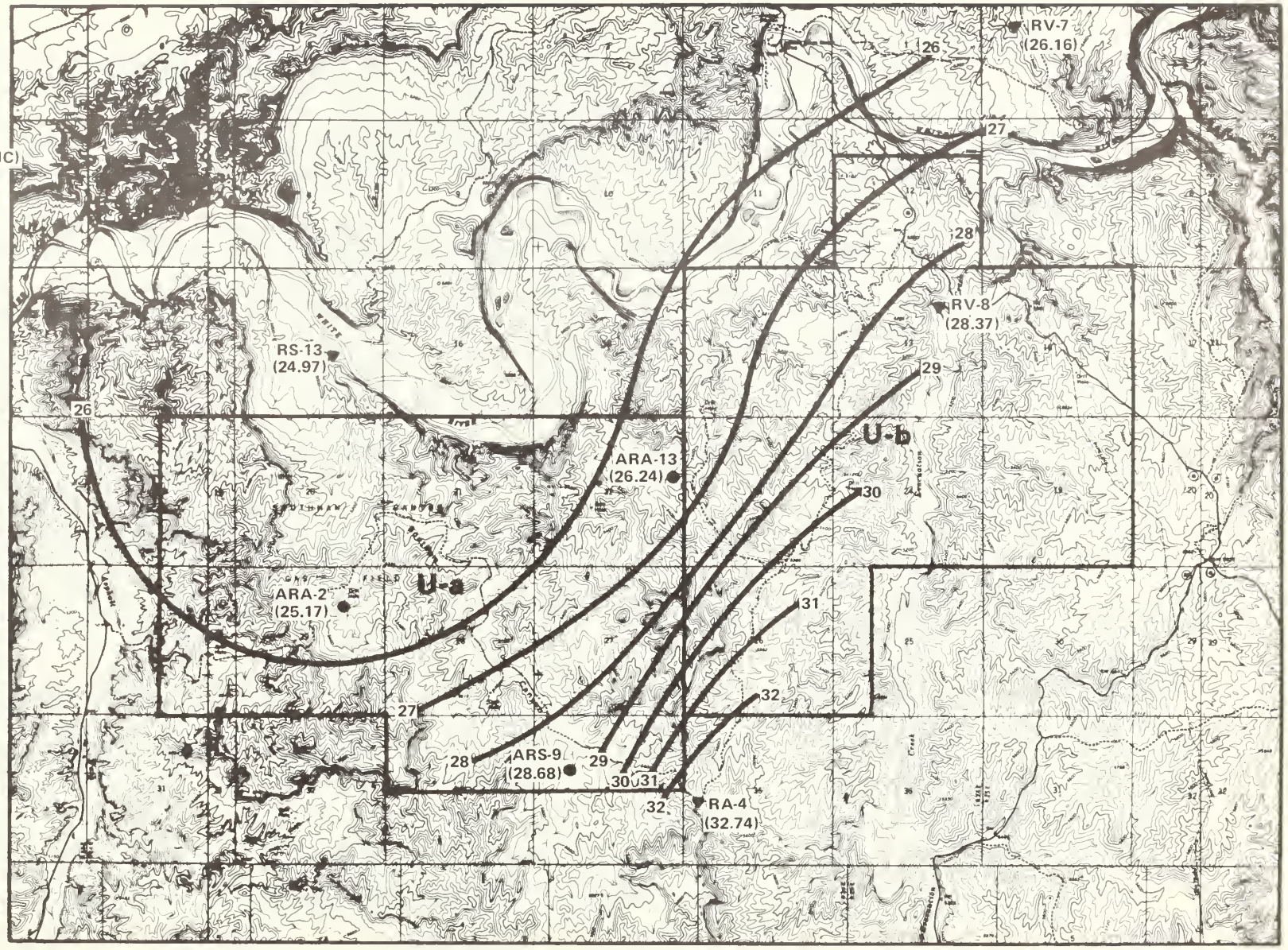
SEASONAL AND ANNUAL PRECIPITATION
October 1978 - September 1979

Station	Fall Oct-Dec	Winter Jan-Mar	Spring Apr-June	Summer July-Sept	1979 Annual Total
ARA-2	2.91 in. (7.39 cm.)	3.60 in. (9.14 cm.)	2.30 in. (5.84 cm.)	1.10 in. (2.79 cm.)	9.91 in. (25.17 cm.)
RA-4	2.98 in. (7.57 cm.)	3.53 in. (8.97 cm.)	2.32 in. (5.89 cm.)	4.06 in. (10.31 cm.)	12.89 in. (32.74 cm.)
ARS-9	3.00 in. (7.62 cm.)	2.99 in. (7.59 cm.)	2.40 in. (6.10 cm.)	2.90 in. (7.37 cm.)	11.29 in. (28.68 cm.)
ARA-13	2.40 in. (6.10 cm.)	3.60 in. (9.14 cm.)	2.20 in. (5.59 cm.)	2.13 in. (5.41 cm.)	10.33 in. (26.24 cm.)
RS-13	2.90 in. (7.37 cm.)	2.55 in. (6.48 cm.)	2.18 in. (5.54 cm.)	2.20 in. (5.59 cm.)	9.83 in. (24.97 cm.)
RV-7	2.97 in. (7.54 cm.)	3.35 in. (8.51 cm.)	2.28 in. (5.79 cm.)	1.70 in. (4.32 cm.)	10.30 in. (26.16 cm.)
RV-8	2.66 in. (6.76 cm.)	3.61 in. (9.17 cm.)	2.31 in. (5.87 cm.)	2.59 in. (6.58 cm.)	11.17 in. (28.37 cm.)
RS-11	3.19 in. (8.10 cm.)	4.46 in. (11.33 cm.)	1.53 in. (3.89 cm.)	1.39 in. (3.53 cm.)	10.57 in. (26.85 cm.)
Average	2.88 in. (7.32 cm.)	3.46 in. (8.79 cm.)	2.19 in. (5.56 cm.)	2.26 in. (5.74 cm.)	10.79 in. (27.40 cm.)

LEGEND

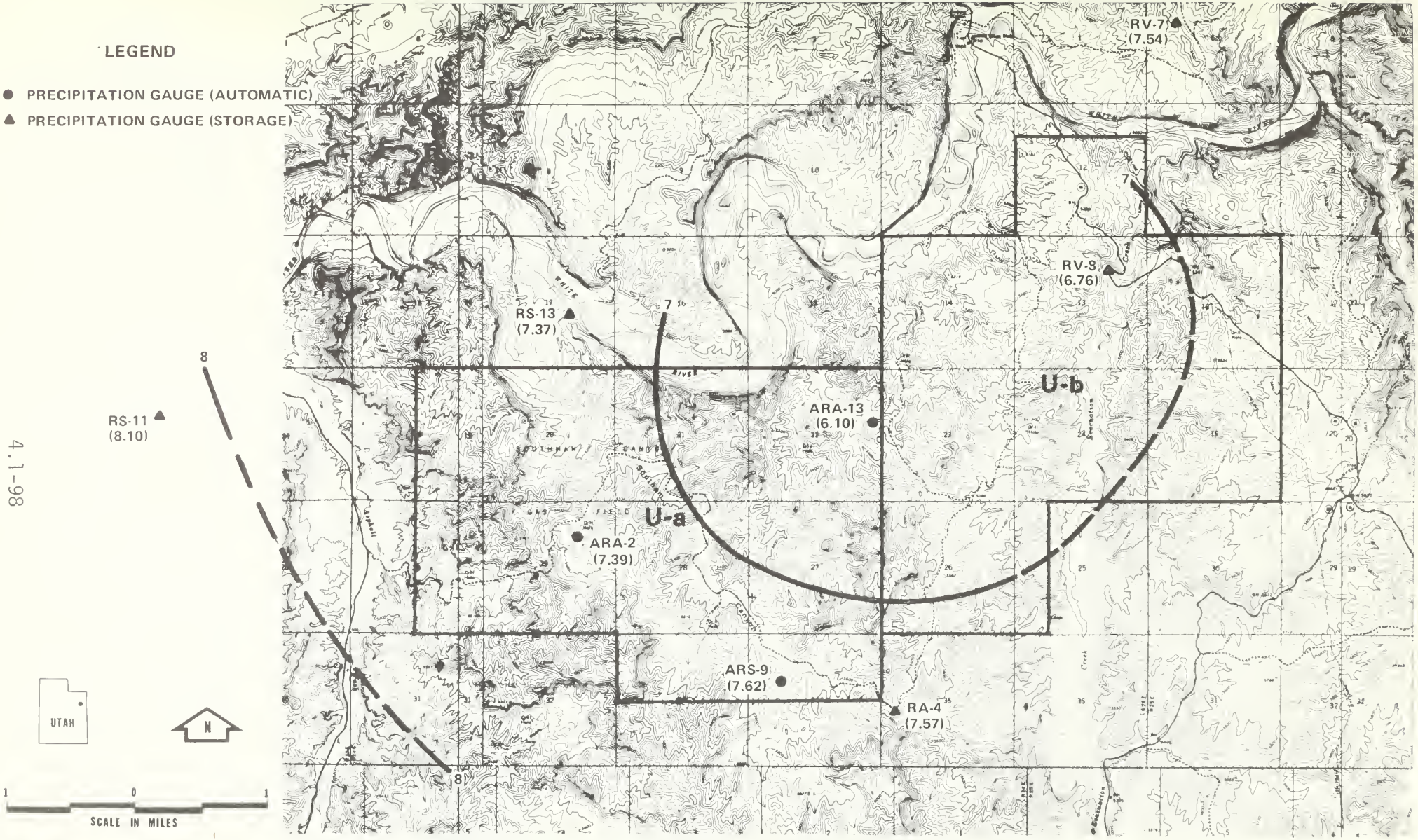
● PRECIPITATION GAUGE (AUTOMATIC)

▼ PRECIPITATION GAUGE (STORAGE)



ANNUAL PRECIPITATION IN CENTIMETERS

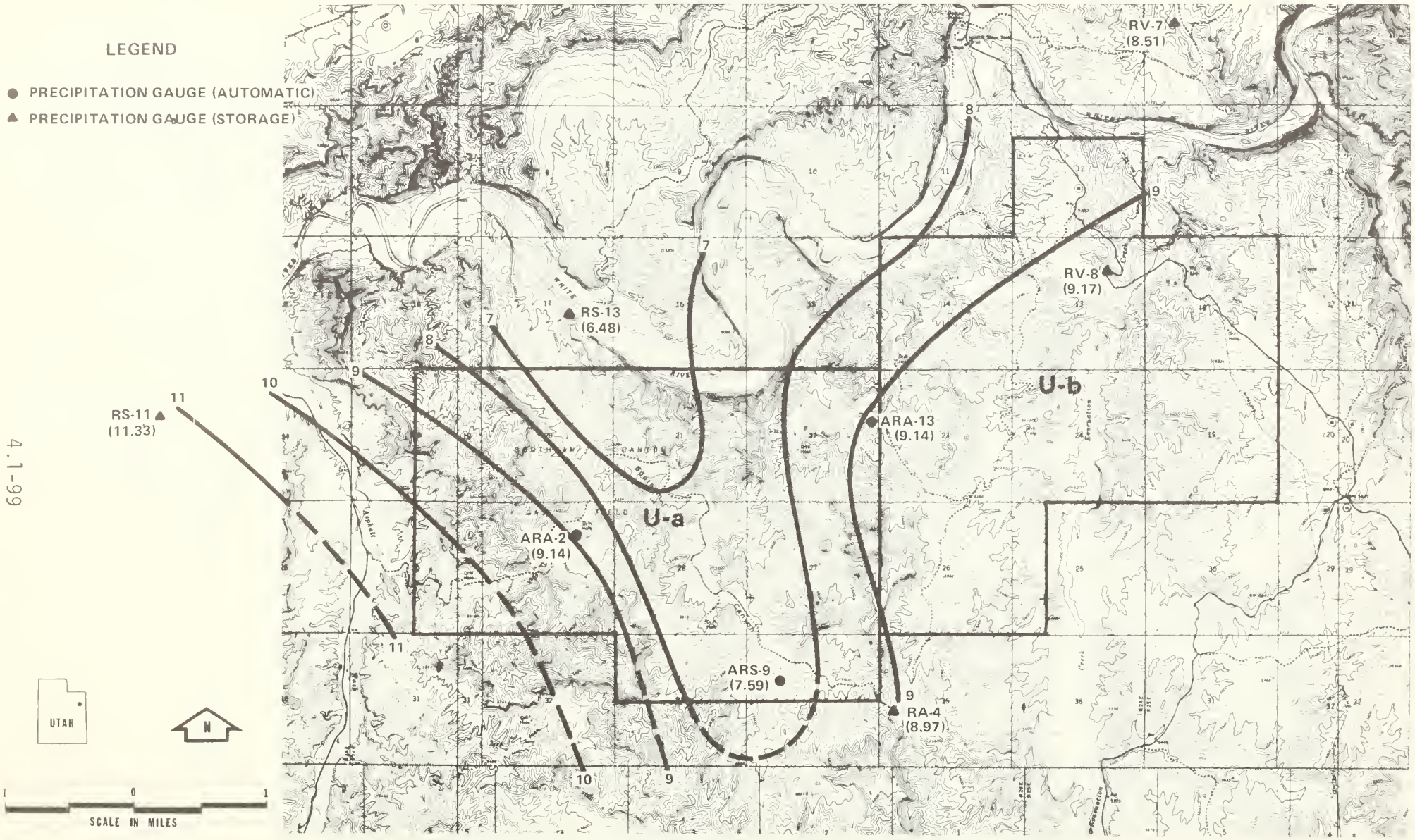
OCT. 1978 – SEPT. 1979



FALL PRECIPITATION IN CENTIMETERS

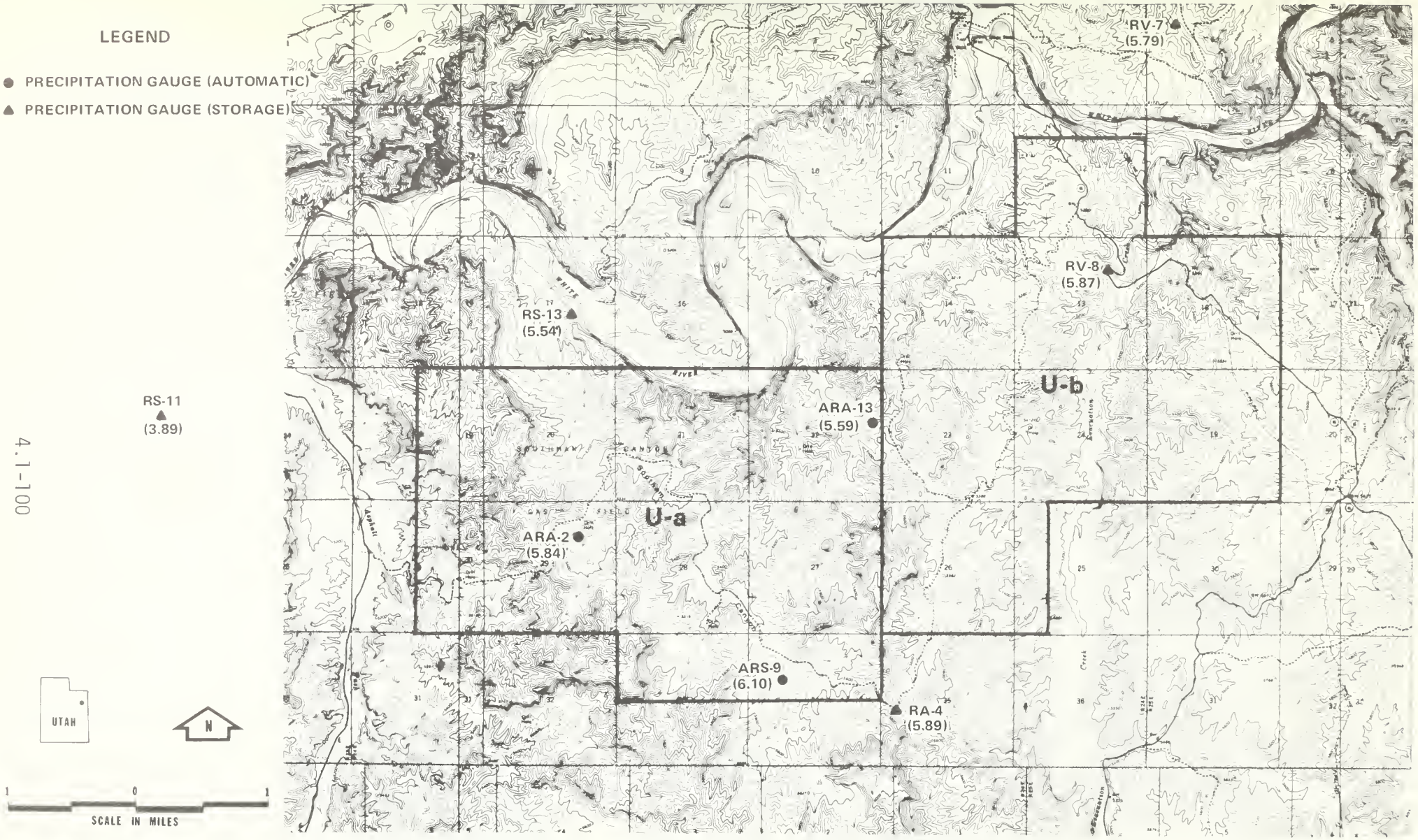
OCT. – NOV. – DEC. 1978

FIGURE 4.1-20



WINTER PRECIPITATION IN CENTIMETERS

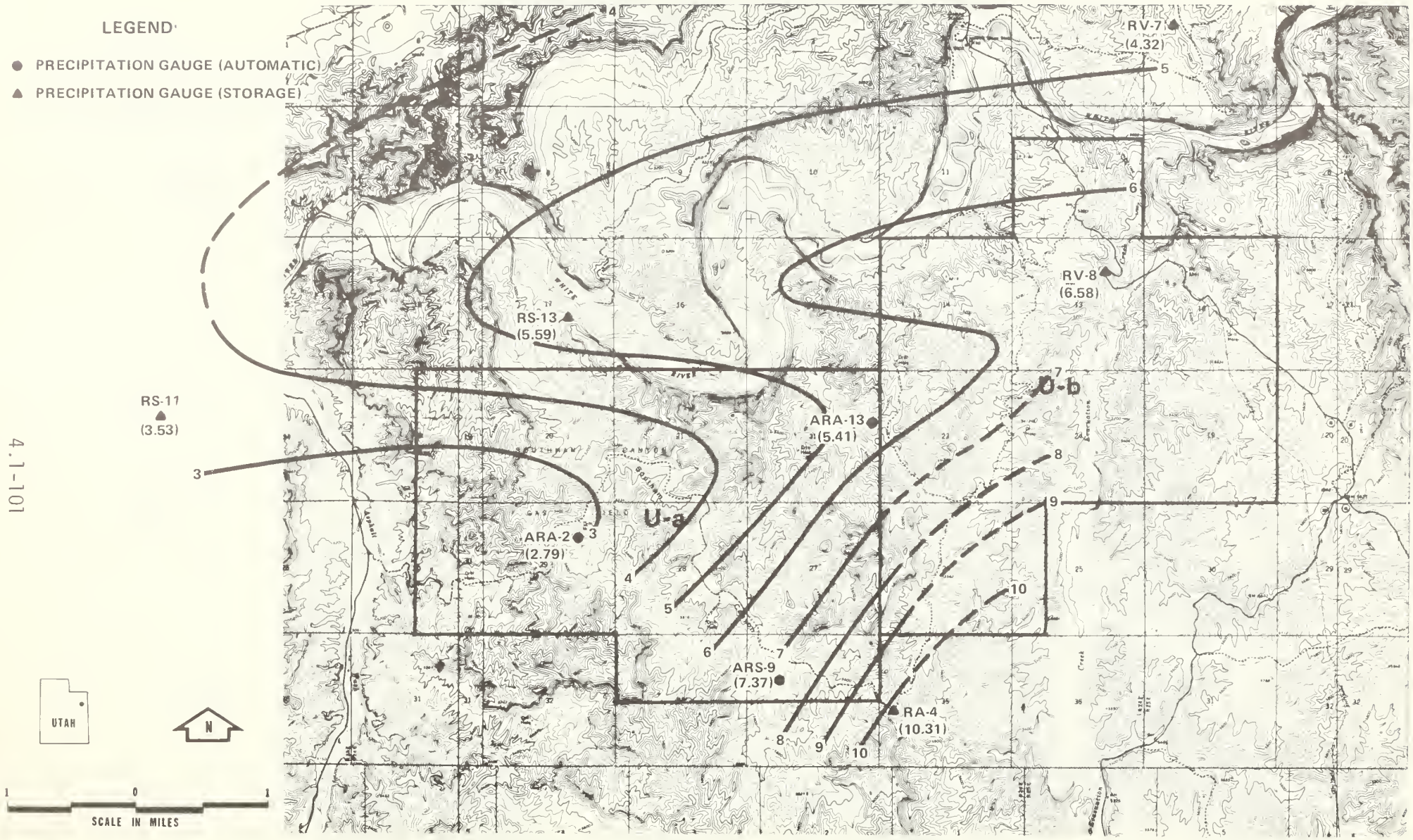
JAN. – FEB. – MAR. 1979



SPRING PRECIPITATION IN CENTIMETERS

APR. – MAY – JUN. 1979

FIGURE 4.1-22



SUMMER PRECIPITATION IN CENTIMETERS

JUL. – AUG. – SEP. 1979

precipitation was 5.74 cm (2.26 inches). As illustrated in Figures 4.1-19 through 4.1-23, precipitation generally increased from northwest to southeast for each season and for the annual total.

Station ARA-13 at the proposed plant site recorded 26.24 cm (10.33 inches) of precipitation during 1979 water year. Precipitation was measured on 47 days during the year at this location. The maximum daily amount of the precipitation at the proposed plant site during the year was 2.79 cm (1.10 inches) on March 28, 1979, and the maximum amount at this site for an event was 4.06 cm (1.6 inches) on March 28 and 29, 1979.

The precipitation data for the thunderstorm on September 26, 1979 are shown in Table 4.1-24. The amount of rainfall from this storm varied considerably, ranging from 0.23 cm (0.09 inches) at RS-13 to 5.92 cm (2.33 inches) at RA-4. This daily total at RA-4 was also the maximum daily precipitation for any of the WRSP gauges during the 1979 water year.

The annual precipitation for the BLM regional network of 13 gauges is tabulated in Table 4.1-25. The annual totals ranged from 60.7 cm (23.9 inches) at South Canyon on the Roan Plateau to 20.3 cm (8.0 inches) at Baeser Wash 18 miles northeast of Ouray. The seasonal distribution of precipitation at these gauges was generally similar to the distribution for the WRSP gauges. Precipitation increases generally corresponded to increased elevation.

TABLE 4.1-24

DAILY PRECIPITATION FOR
SEPTEMBER 26, 1979

Station	Precipitation	
	Inches	Centimeters
ARA-2	0.10	0.25
RA-4	2.33	5.92
ARS-9	1.40	3.56
ARA-13	0.30	0.76
RS-13	0.09	0.23
RV-7	0.25	0.64
RV-8	0.55	1.40
RS-11	0.19	0.48

TABLE 4.1-25

ANNUAL PRECIPITATION
BUREAU OF LAND MANAGEMENT REGIONAL PRECIPITATION NETWORK
October 1978 - September 1979

Location Name	Gauge Number*	Inches	Centimeters
Seely Cabin	28	10.9	27.7
Boulevard Ridge	29	15.5	39.4
Mayo Cabin	30	10.6	26.9
Cottonwood	31	9.6	24.4
Winter Ridge	32	11.9	30.2
South Canyon	33	23.9	60.7
Tom Patterson	34	14.8	37.6
Krugerfritz	35	9.4	23.9
Miners Gulch	36	12.7	32.3
Davis Spring	37	10.4	26.4
Deadman	38	8.2	20.8
Baeser Wash	39	8.0	20.3
Blue Mountain	40	14.5	36.8

* Refers to locations shown in Figure 4.1-18.

Evaporation

The pan evaporation data for stations EVP-2 and EVP-13 for the freeze-free period from May through September 1979 are shown in Table 4.1-26. The net evaporation for the period at stations EVP-2 and EVP-13 was 87.89 cm (34.32 inches) and 54.42 cm (21.42 inches), respectively; total evaporation for the period was 94.24 cm (36.82 inches) and 63.64 cm (25.05 inches). The greatest monthly amount of evaporation occurred in July at EVP-2 and in June at EVP-13. As in previous years of record, the evaporation was considerably greater at EVP-2 than at EVP-13. It is probable that the evaporation data for EVP-13 are not representative of that area. It was recently determined that this evaporation pan is located such that it is partially sheltered from wind from the east, which could substantially reduce evaporation from the pan. The pan was moved to a more appropriate nearby location prior to May 1980.

4.1.4.4 Conclusions. The average annual precipitation for the project area is about 25.4 cm (10 inches), varying from about 23 cm (9 inches) in the northwest area of the tracts to about 28 cm (11 inches) in the southeast area, based on regional historic data (presented in the FEBR).

Annual precipitation during water years 1975 through 1979 at the present WRSP gauge locations is shown in Table 4.1-27. The data shown for station RV-8 during 1975 were collected at station RS-2 (near surface water station 6430) which was located only a few hundred feet from the present location of RV-8. The data illustrate that the annual

TABLE 4.1-26

PAN EVAPORATION RECORDS
MAY-SEPTEMBER 1979

	EVP-2/ARA-2			EVP-13/ARA-13		
	Net Evaporation	Precipitation	Total Evaporation	Net Evaporation	Precipitation	Total Evaporation
May	4.65 in. (11.81 cm.)	1.20 in. (3.05 cm.)	5.85 in. (14.86 cm.)	2.52 in. (6.40 cm.)	1.40 in. (3.56 cm.)	3.92 in. (9.96 cm.)
June	7.42 in. (18.85 cm.)	0.20 in. (0.51 cm.)	7.62 in. (19.36 cm.)	5.78 in. (14.68 cm.)	0.10 in. (0.25 cm.)	5.88 in. (14.93 cm.)
July	8.80 in. (22.35 cm.)	0.20 in. (0.51 cm.)	9.00 in. (22.86 cm.)	4.75 in. (12.07 cm.)	0.90 in. (2.29 cm.)	5.65 in. (14.36 cm.)
August	6.35 in. (16.13 cm.)	0.80 in. (2.03 cm.)	7.15 in. (18.16 cm.)	4.05 in. (10.29 cm.)	0.93 in. (2.36 cm.)	4.98 in. (12.65 cm.)
September	7.10 in. (18.03 cm.)	0.10 in. (0.25 cm.)	7.20 in. (18.28 cm.)	4.32 in. (10.97 cm.)	0.30 in. (0.76 cm.)	4.62 in. (11.73 cm.)
May-Sept.	34.32 in. (87.89 cm.)	2.50 in. (6.35 cm.)	36.82 in. (94.24 cm.)	21.42 in. (54.42 cm.)	3.63 in. (9.22 cm.)	25.05 in. (63.64 cm.)

TABLE 4.1-27

ANNUAL PRECIPITATION FOR
WATER YEARS 1975 THROUGH 1979

Station	Water Year 1975	1976	1977	1978	1979
ARA-2		9.60 in. (24.38 cm.)	6.00 in. (15.24 cm.)		9.91 in. (25.17 cm.)
RA-4					12.89 in. (32.74 cm.)
ARS-9	10.59 in. (26.90 cm.)	10.21 in. (25.93 cm.)			11.29 in. (28.68 cm.)
ARA-13		9.20 in. (23.37 cm.)	6.00 in. (15.24 cm.)	6.50 in. (16.51 cm.)	10.33 in. (26.24 cm.)
RS-13	8.57 in. (21.78 cm.)	9.79 in. (24.87 cm.)			9.83 in. (24.97 cm.)
RV-7				8.10 in. (20.57 cm.)	10.30 in. (26.16 cm.)
RV-8	9.09 in.* (23.10 cm.*)			6.38 in. (16.21 cm.)	11.17 in. (28.37 cm.)
RS-11	8.14 in. (20.68 cm.)				10.57 in. (26.85 cm.)
Average	9.10 in. (23.11 cm.)	9.70 in. (24.64 cm.)	6.00 in. (15.24 cm.)	6.99 in. (17.76 cm.)	10.79 in. (27.40 cm.)

*Gauge RS-2

precipitation for the 1979 water year was generally greater than the annual values for the 1975 through 1978 water years. Also, the 1979 annual total was slightly greater than the estimated historic average annual precipitation for the area. This was primarily due to increased precipitation during the fall and winter months of the 1979 water year.

The precipitation event of March 28 and 29, 1979, was relatively intense, totaling greater than 2.5 cm (one inch), and was more or less uniform across the tracts. The only other intense precipitation event during the year occurred on September 26, 1979 and was caused by an isolated thunderstorm. This event led to flash floods in Southam Canyon and in Evacuation Creek. The variations in the 1979 annual precipitation at the various WRSP gauge locations were apparently influenced more by this one isolated thunderstorm than by elevation differences between the gauges.

The records of the net pan evaporation at stations EVP-2 and EVP-13 for the May through September periods of 1975 through 1979 are shown in Table 4.1-28. The net pan evaporation at EVP-2 during 1979 was within the range of values from the previous four years. The data from station EVP-13 are probably not representative, so no conclusions will be drawn from them.

the "total" amount (that is, less than 95 percent) of the constituent present in the dissolved and suspended phases of the sample. To achieve comparability of analytical data, equivalent digestion procedures would be required of all laoratories performing such analyses because different digestion procedures are likely to produce different analytical results.

Total is the total amount of a given constituent in a representative water-suspended sediment sample, regardless of the constituent's physical or chemical form. This term is used only when the analytical procedure assures measurement of at least 95 percent of the constituent present in both the dissolved and suspended phases of the sample. A knowledge of the expected form of the constituent in the sample, as well as the analytical methdology used, is required to judge when the results should be reported as "total." (Note that the word "total" does double duty here, indicating both that the sample consists of a water-suspended sediment mixture and that the analytical method determines all of the constituent in the sample.)

Source: U.S. Geological Survey, Water Data Reports UT-78-1 (August 1979) and CA-78-1 (April 1980).

ERRATA
Progress Report - 1978
Section 4.1

Page 4-20: The first page of Table 4-5 was left out of the report. The entire table has been presented in the 1979 report as Table 4.1-7.

Page 4-31: In Figure 4-10, the vertical axis for Chemical Oxygen Demand should be: 0,30,60,90,120, and 150 mg/l.

Page 4-61: The first sentence of the second paragraph should read: ". . . during the first two years of record. . . ."

4.2 AIR RESOURCES

The Interim Air Resources Monitoring Program was designed as a systematic step between the Baseline Monitoring Program and the Development Monitoring Program. The two-year Baseline Program began late in 1974 and was complete by January 1977. The baseline years referred to in this section are 1975 and 1976. The Interim Program commenced in January, 1977 with the continuing collection of pertinent air quality and meteorological parameters. During 1977, 1978, and 1979, four meteorological monitoring stations (A-4, A-6, A-11, and A-13) were operated with one site (A-6) used for air quality monitoring as well.

Figure 4.2-1 shows the locations of the air quality and meteorological sites operated by AeroVironment for White River Shale Project on Tracts Ua and Ub..

Data for 1977 and 1978 were analyzed and summarized in previous progress reports. The analyses and summarizations of the data collected during the interim monitoring year 1979 are presented here.

4.2.1 Air Quality Monitoring Program

4.2.1.1 Objectives. The prime objective of this Interim Program was to determine if the occasional high levels of ozone and non-methane hydrocarbons noted during the Baseline period recurred during the lease suspension period. Another objective was to maintain continuity of data on other air quality parameters and to note any significant deviations of values of these parameters from those observed during the Baseline Program.

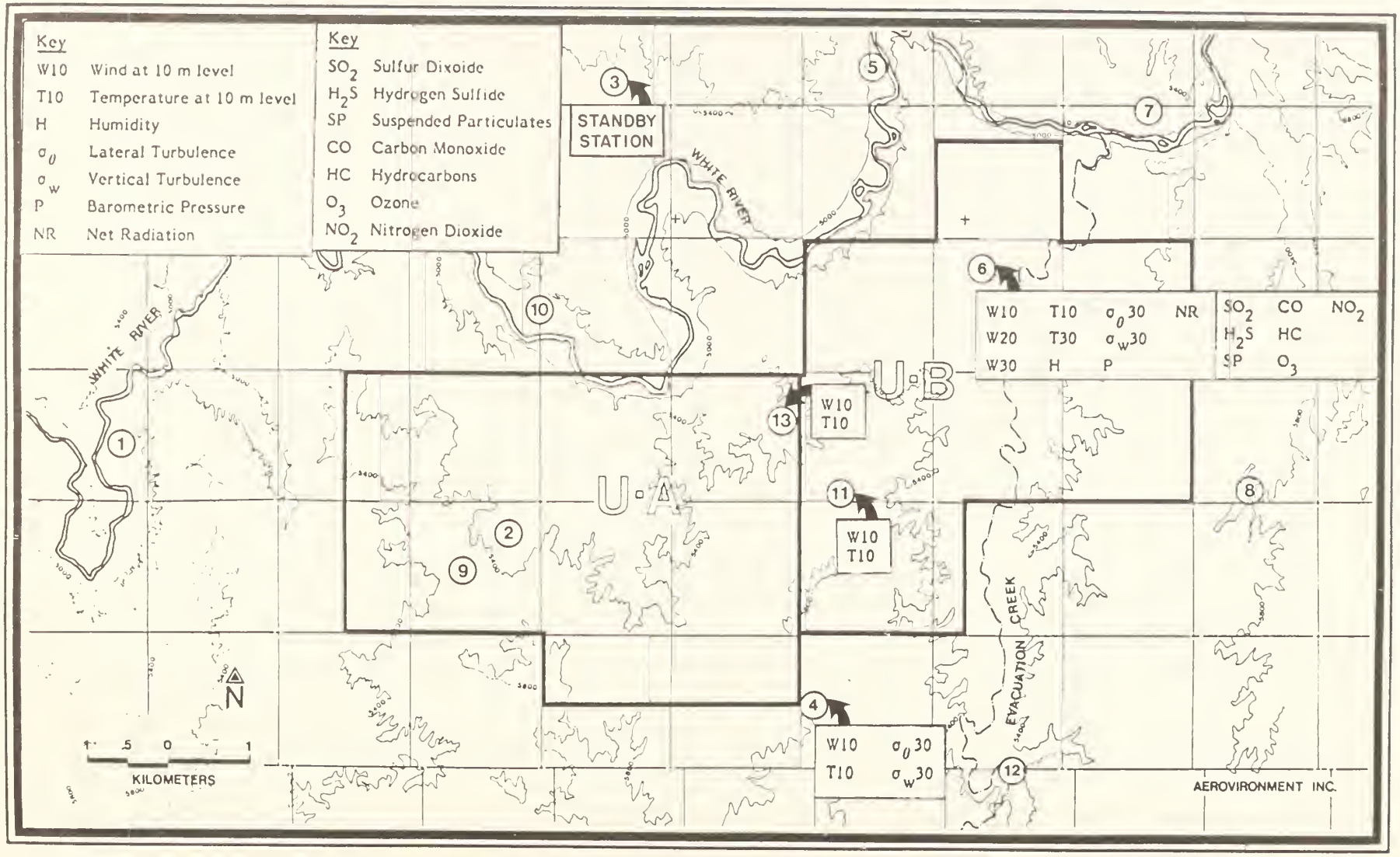


FIGURE 4.2-1 Locations of meteorological and air quality measurement stations on Tracts Ua and Ub.

4.2.1.2 Methods. Site A-6 (see Figure 4.2-1) has continued operation during the suspension period. The monitoring parameters for Site A-6 are identical to those used during the Baseline Program. Table 4.2-1 lists the instruments used and the parameters measured. All parameters, except total suspended particulates, are monitored continuously. Data are recorded on digital punch tapes every six minutes and on strip charts every two minutes.

Site A-3 is available on standby. Site A-3 includes the same instrumentation as A-6 and would be put into service if A-6 became inoperable.

Total suspended particulates are measured over a 24-hour period at A-6 every sixth day. This schedule is the same as used in the Baseline Monitoring Program and is considered sufficient for continued characterization of the randomly produced background particulate levels. The specific measurement techniques used are the same as those used during the Baseline Program, which have been described extensively in previous reports on that program.

Quality assurance was provided through four techniques. First, all the instruments used were audited four times during the year. Second, the air quality equipment was recalibrated (dynamic multiple point) monthly. Third, the equipment received span and zero checks every two days. This schedule of calibration is more frequent than that for the Baseline Program and reflects the greater reliability demanded of a single air monitoring station. Fourth, in addition to the normal internal quality assurance procedures maintained by AeroVironment, the White River Shale Project has participated voluntarily in an air pollution measurement quality assurance program implemented by the U. S. Environmental Protection Agency.

TABLE 4.2-1. Air quality monitoring equipment (Site A-6).

Parameter	Instrument
Suspended Particulates	General Metals Model 5000 Hi-Vol with constant flow control
Sulfur Dioxide Hydrogen Sulfate Total Sulfur	Tracor Model 270 HA sulfur analyzer, gas chromatography
Nitrogen Oxides (NO, NO_x, CH_4)	Monitor Labs Model 8440E NO/NO_x analyzer, chemiluminescence
Hydrocarbons (THC, CH_4)	Beckman Instruments Model 6800 gas chromatograph, flame ionization
Carbon Monoxide	Beckman Instruments Model 6800 gas chromatograph, flame ionization
Oxidants (O_3)	Monitor Labs Model 8410E ozone analyzer, chemiluminescence

An in-depth description of the quality assurance program is contained in the report "Quality Assurance Plan for Air Resources Monitoring, Oil Shale Lease Tracts Ua-Ub" (AV-QA-8047, AeroVironment Inc., 1978).

4.2.1.3 Present Status and Plans for 1980. The extent of the air quality data collected during 1979 is tabulated in Table 4.2-2. This table lists the percentage of hours during which data were collected for each parameter. Calibration time is counted as data collection time.

The plans for 1980 are to continue with data collection operations as in 1979.

4.2.1.4 Data Summary

Gaseous Pollutants

Both gaseous and particulate air quality measurements are made at Site A-6. Utah State air quality standards for gaseous pollutants are the same as the Federal standards. For reference in the ensuing discussions, Table 4.2-3 presents the National Ambient Air Quality Standards (NAAQS) for the various gaseous pollutants monitored on the tracts. The new ozone standard of 235 $\mu g/m^3$ (0.12 ppm) went into effect on January 26, 1979. Since there is no state or federal air quality standard for H_2S, a reference for interpreting the data is the California one-hour standard of 42 $\mu g/m^3$ (0.03 ppm).

The air quality continued to be consistently good on the tracts. During this study period, except for sporadic occurrences of high non-methane hydrocarbon (NMHC), air quality on the tracts was very clean with respect to gaseous pollutants. The only other pollutant present in

TABLE 4.2-2. Percentage of time monitoring was performed for air quality parameters during period 1 January - 31 December 1979.

Component	Number of Stations	Percentage
SO_2	1	99
H_2S	1	99
Total HC	1	94
NO_x	1	84
O_3	1	96
CO	1	95
Suspended Particulates	1	88

TABLE 4.2-3. Federal and Utah air quality standards for gaseous pollutants.

Pollutant	Averaging Time	Primary Standards	Secondary Standards
Ozone (O_3)	1-hour	235 $\mu g/m^3$ (0.12 ppm)	Same as primary
Carbon Monoxide	8-hour	10 mg/m^3 (9 ppm)	Same as primary
	1-hour	40 mg/m^3 (35 ppm)	Same as primary
Sulfur Dioxide (SO_2)	annual average	80 $\mu g/m^3$ (0.03 ppm)	-
	24-hour	365 $\mu g/m^3$ (0.14 ppm)	-
	3-hour	-	1300 $\mu g/m^3$ (0.5 ppm)
Nitrogen Dioxide (NO_2)	annual average	100 $\mu g/m^3$ (0.05 ppm)	Same as primary
Hydrocarbons (corrected for methane - NMHC)	3-hour (6-9 a.m.)	160 $\mu g/m^3$ (0.24 ppm)	Same as primary

measurable quantities was ozone, which has a natural non-zero background level. Otherwise, almost all instruments measuring gaseous pollutants were recording at their threshold limit most of the time, the same as during the Baseline period.

Comparisons of 1979 data with Baseline monitoring data were made to detect any significant changes. Generally, the data exhibit no significant abnormalities with respect to the Baseline data. Specific comments are included with the discussion of each parameter, when appropriate.

1. Ozone (O_3)

Plots of diurnal variations of O_3 at Site A-6 for January and July, 1979 are shown in Figures 4.2-2 and 4.2-3, respectively. The average diurnal trend indicates lower values in the early morning hours and higher values in the afternoon hours.

The mean Baseline hourly values are also shown. The average ozone value for January, 1979 was 20 $\mu g/m^3$ to 30 $\mu g/m^3$ greater than the average Baseline ozone value. The frequent frontal passages of January, 1979 with accompanying stratospheric ozone incursions (Signh et al., 1979) could have caused the higher values and the small diurnal changes. In July 1979, ozone values averaged slightly less than Baseline. The nominal detection limit for the ozone analyzer is 2 $\mu g/m^3$ and the instrument's precision is ± 10 $\mu g/m^3$.

The peak hour, second highest hour, average seasonal values, and number of exceedances are tabulated in Table 4.2-4. The highest hourly value during 1979 was 151 $\mu g/m^3$, and the second highest value was 149 $\mu g/m^3$. The average values by seasons of the year varied between 63 $\mu g/m^3$ and 78 $\mu g/m^3$, which is around the typical global background value.

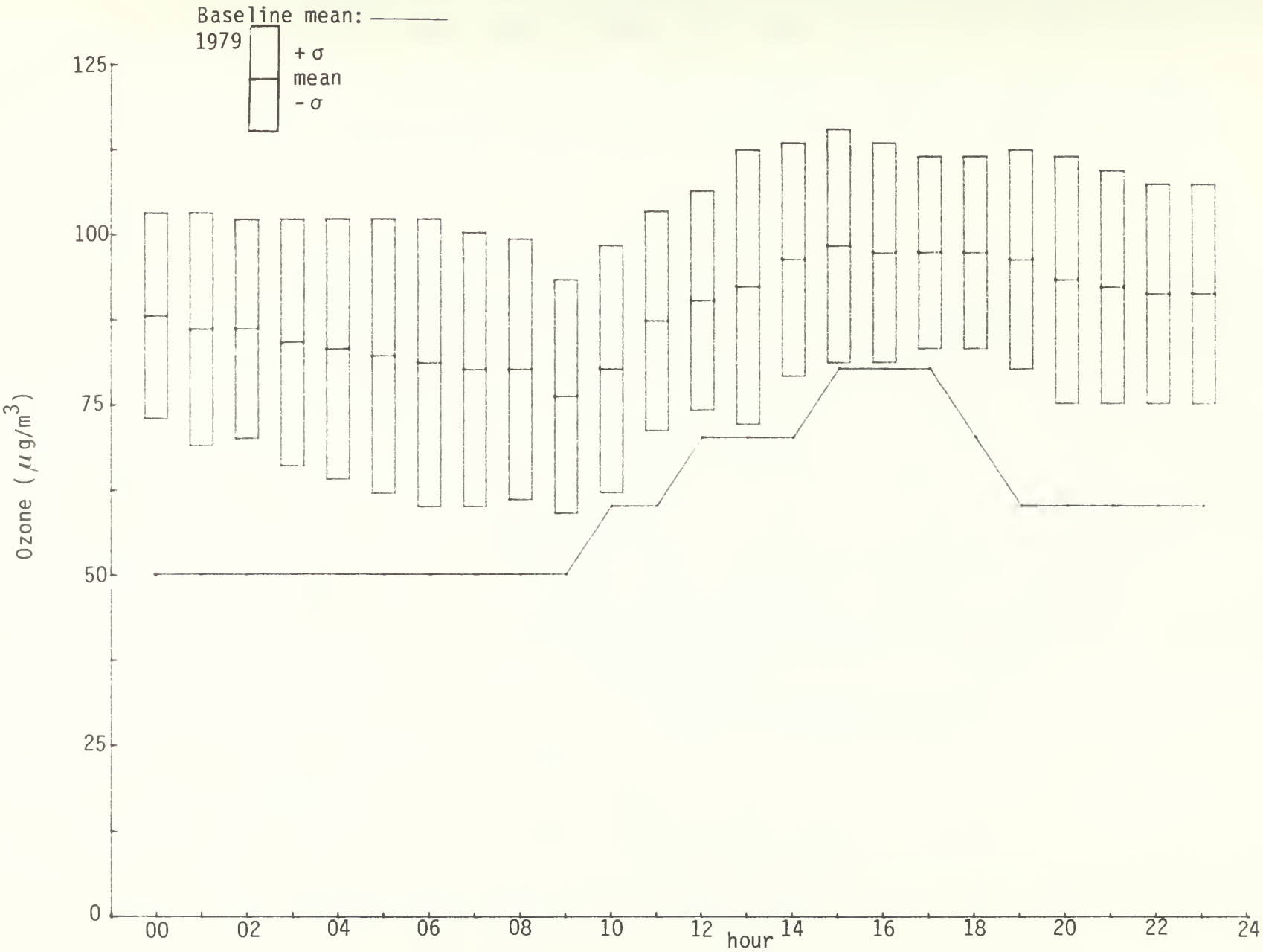


FIGURE 4.2-2. Diurnal variation of mean ozone concentrations and their standard deviations compared with the Baseline mean values at Site A6 during January 1979.

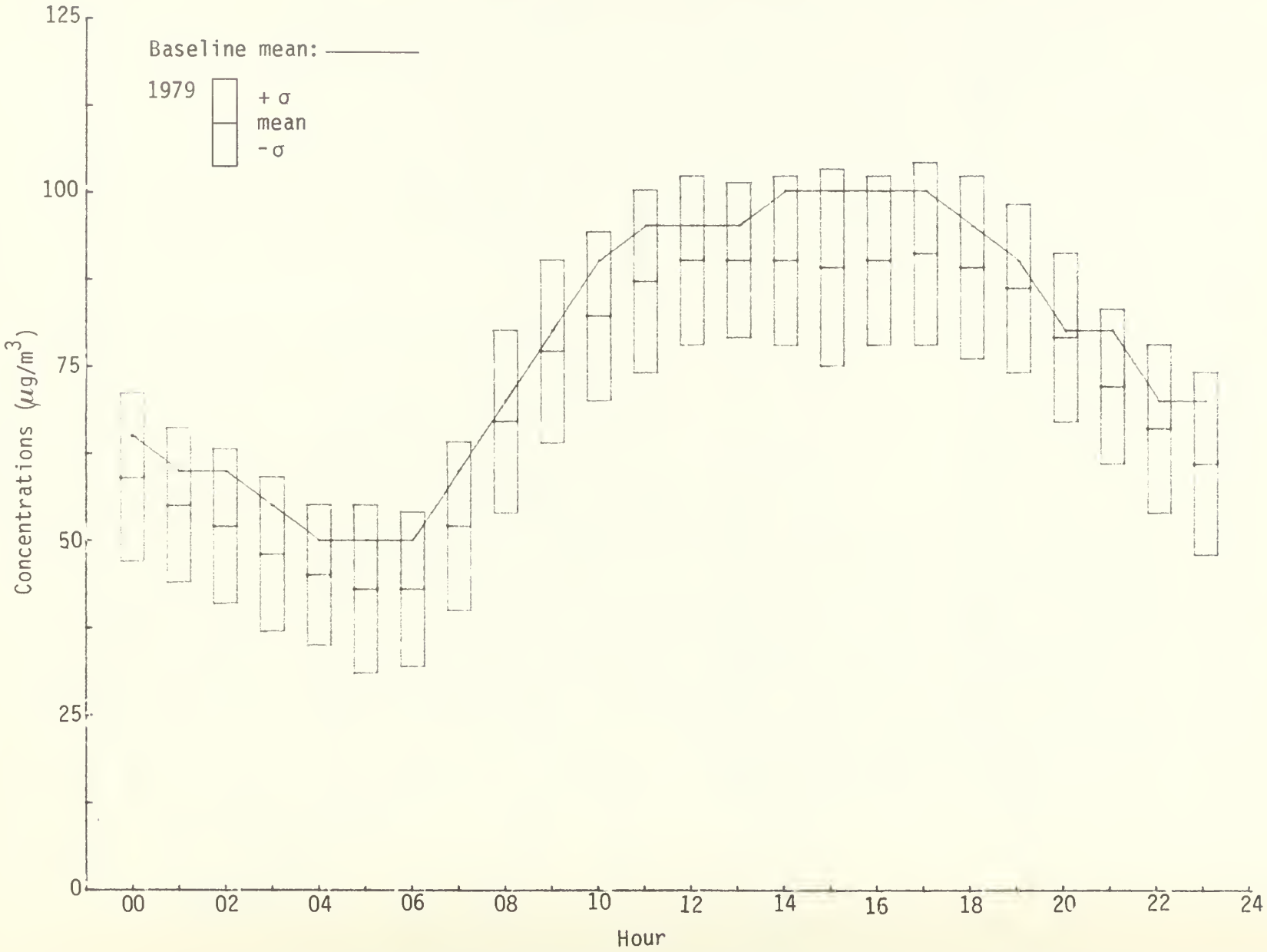


FIGURE 4.2-3. Diurnal variation of mean ozone concentrations with their standard deviations compared with Baseline means at Site A6 during July 1979.

TABLE 4.2.4. Comparison of the highest, second highest and average 1-hour O_3 readings (in $\mu g/m^3$) as well as the percent of observations exceeding the standard (235 $\mu g/m^3$) at Site A6 from the Baseline Period (1975-1976) and 1979.

Season	Peak Concentration		Second Highest Concentration		Average		No. of Observations		Number of Exceedances of Standard	
	Baseline	1979	Baseline	1979	Baseline	1979	Baseline	1979	Baseline	1979
Winter	150	149	150	147	70	78	2,872	2,064	0	0
Spring	150	145	140	143	75	76	4,033	2,067	0	0
Summer	140	151	140	145	75	76	4,135	2,161	0	0
Fall	140	149	120	137	55	63	4,244	1,881	0	0

The peak and second highest concentrations were comparable to those observed during the Baseline years, as were averages for spring and summer. The winter average was higher than the Baseline value, probably due to the more frequent-than-normal stratospheric intrusions of ozone during several frontal passages during January and February of 1979. The average fall ozone value was also higher than that observed during the Baseline years. This is attributed to the many days of stagnation conditions with high daytime ozone values in September, 1979.

Figure 4.2-4 shows the monthly maximum and mean hourly values and means, as well as the mean daily maximum hourly averages for 1979 compared to the Baseline period. The highest maximums and means occur from late winter through summer. The lowest averages occur during the fall months. Again, the mean monthly values for January and February, 1979 were much higher than Baseline values. The mean daily maximum hourly averages for these months, plus June and September, were also higher than the Baseline values.

This seasonal variation in ozone concentration is best explained by Figure 4.2-5, which is an excerpt from a report by Singh, et al. (1977). The existence of a large natural ozone reservoir in the troposphere, especially in late winter and early spring, could account for the high readings on Tracts Ua-Ub during that period. Throughout summer, high ozone reading can probably be attributed to ozone generation from local or transported precursors, with occasional long-range transport from urban areas.

Figure 4.2-6 shows the trend in the annual averages of ozone at Site A-6 since 1975. After three years of decreasing ozone concentrations, 1979 averaged almost as high as 1975. A check with the State Agency of Utah corroborates the trends at Site A-6 with those at Salt Lake City, Bountiful, and Provo.

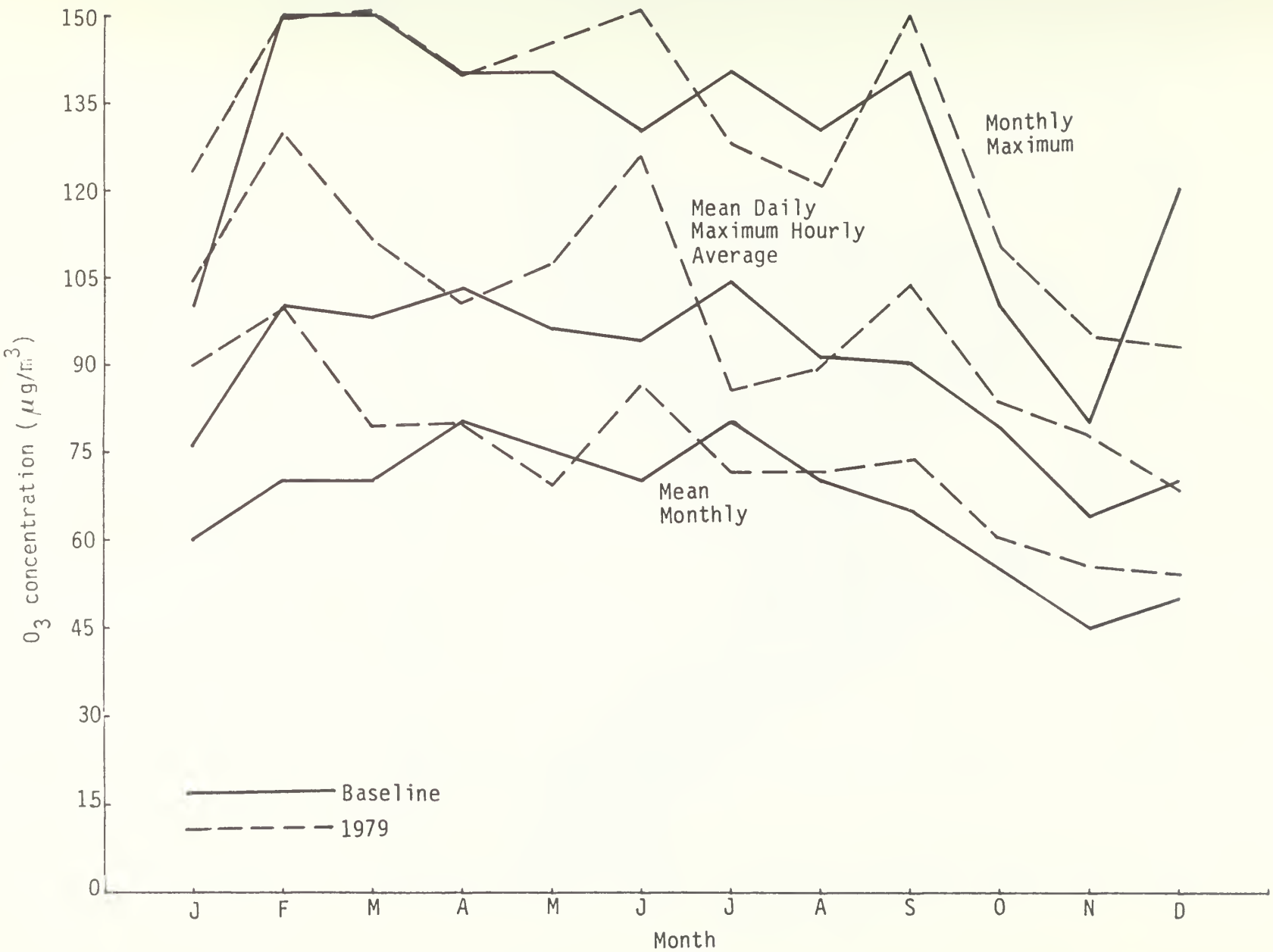


FIGURE 4.2-4 Monthly maximum hourly value, mean daily maximum hourly average, and mean monthly value for O_3 at Site A6 for 1979 compared to the Baseline period.

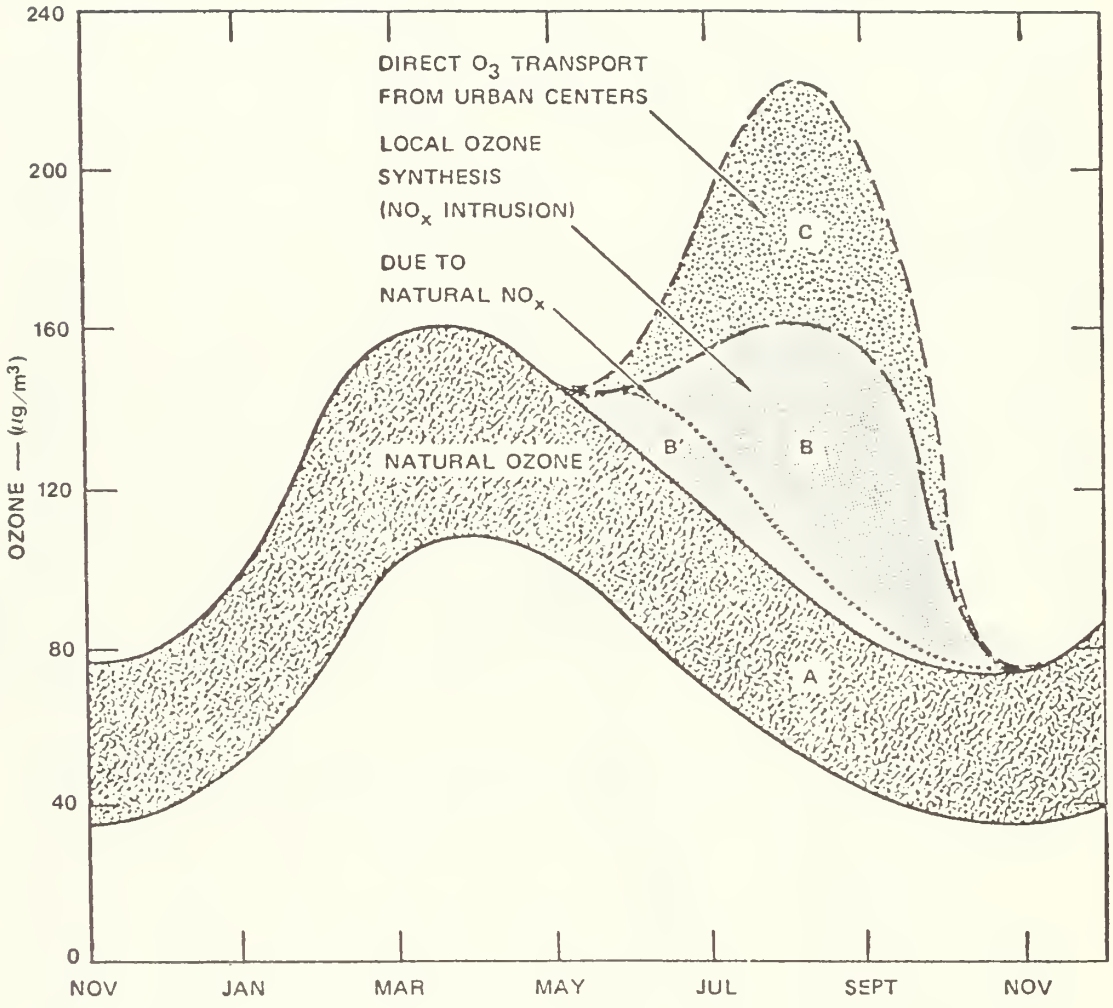


FIGURE 4.2-5. Idealized ozone variations at remote locations (Source: Singh, et al., 1978).

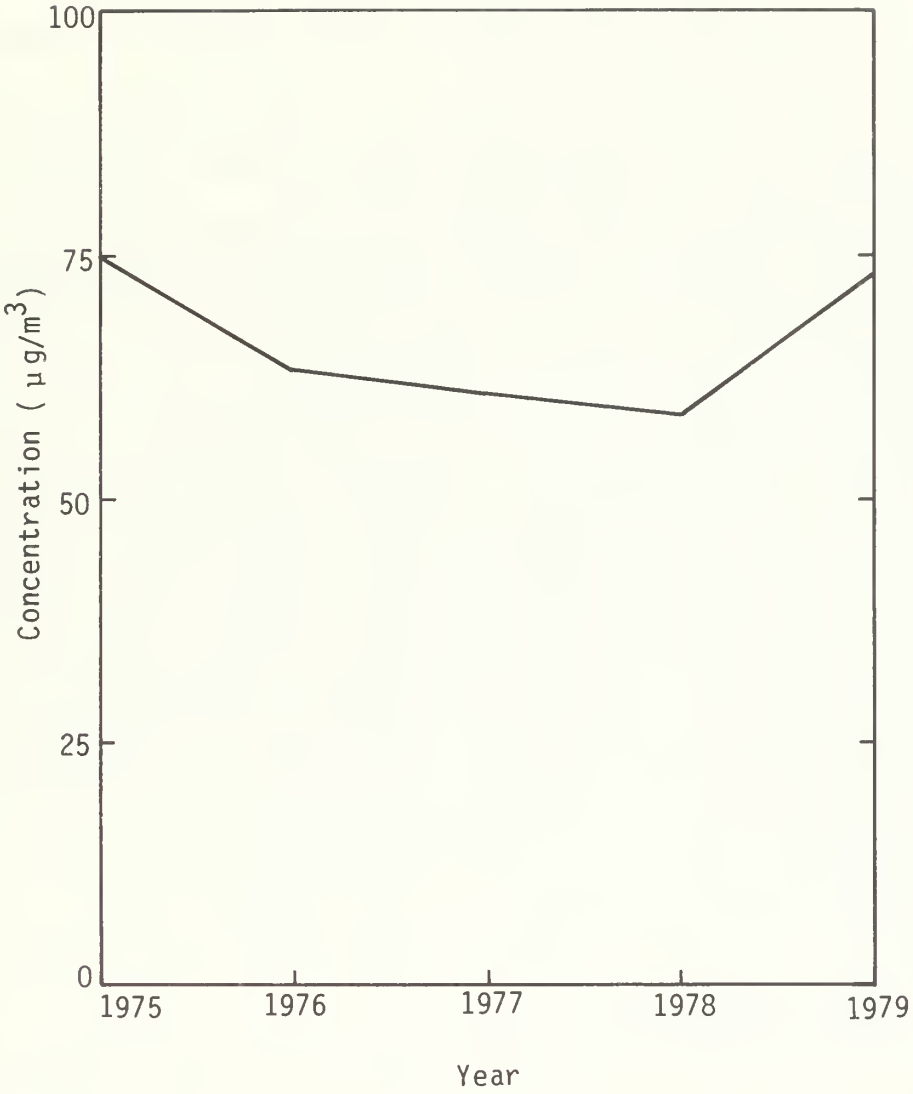


FIGURE 4.2-6. Trend of annual average O_3 at Site A6.

Table 4.2-5 gives the monthly averages of ozone for the last five years. Table 4.2-6 shows the number of cases by month when ozone readings were $\geq$100 $\mu g/m^3$ during frontal or storm passages. High incidences of frontal passages accompanied by stratospheric intrusions, especially during the period January through May, appear to have contributed to some of the high values recorded during this time. Few frontal passages occurred in January and February of 1976 and 1977, whereas January and February 1978 and 1979 were months with several intrusions of stratospheric ozone.

Although the early part of 1978 had slightly more frontal passages than 1979, the number of cases with ozone $\geq$100 $\mu g/m^3$ were fewer. The storm fronts during January through April 1978 originated from the west and southwest with milder temperatures. By May 1978 the frontal origins were more arctic. That month averaged the highest ozone during the past five years. The corresponding period in 1979 saw somewhat fewer storm passages but more ozone intrusions. This year the storms were mostly of polar origin, suggesting the possibility that the origin, as well as the direction and intensity of each system, are factors to be considered in stratospheric ozone intrusions.

2. Carbon Monoxide (CO)

Table 4.2-7 presents the highest, second highest and average one-hour and eight-hour CO concentrations at Site A-6. During 1979, the maximum one-hour was 1.8 mg/m^3 and 1.8 mg/m^3 measurements recorded during the Baseline period. However, all values were well-below the national standards of 40 mg/m^3 (one-hour) and 10 mg/m^3 (eight-hour).

Contamination of CO readings by generator exhaust was a problem during the first part of the Baseline period. The normal background level is

TABLE 4.2-5. Summary of monthly averages of ozone ($\mu g/m^3$) during the last five years at Site A6.

Month	Year					Average
	1975	1976	1977	1978	1979	
Jan	-	60	45	71	89	66
Feb	80	60	60	80	99	76
Mar	70	70	70	68	79	71
Apr	90	70	70	77	79	77
May	80	70	70	87	69	75
Jun	70	70	80	68	86	75
Jul	80	80	60	88	71	76
Aug	80	60	70	75	71	71
Sep	80	50	60	60	73	65
Oct	60	50	50	51	60	54
Nov	40	50	50	62	55	51
Dec	40	60	50	71	54	55
Annual	75	63	61	58	74	66

TABLE 4.2-6. Number of cases of frontal passages (by month) accompanied by readings of ozone $\geq 100\ \mu g/m^3$ during nightime hours at Site A6.

Month	Year					Totals
	1975	1976	1977	1978	1979	
Jan	8/1	2/0	2/1	8/3	8/7	27/10
Feb	6/3	6/0	5/0	6/3	7/7	30/10
Mar	7/4	6/2	6/2	8/3	6/2	34/10
Apr	6/3	7/1	6/2	9/3	5/3	34/12
May	6/2	5/1	7/3	9/6	6/2	33/15
Jun	6/1	6/1	5/2	5/1	4/2	26/7
Jul	4/1	4/2	6/1	4/1	4/1	22/6
Aug	5/1	4/0	3/1	6/2	3/1	21/5
Sep	3/1	3/0	4/0	6/0	4/0	20/1
Oct	5/0	2/0	5/0	6/0	8/2	26/2
Nov	5/0	1/0	7/0	5/0	3/0	21/0
Dec	4/0	3/1	4/0	7/4	4/0	22/5
Annual	57/17	49/9	60/13	79/22	63/27	307/85

TABLE 4.2-7. Comparisons of the peak, second highest, and average 1-hour and 8-hour moving mean CO readings (in mg/m^3), as well as the number of observations exceeding the standard (40 mg/m^3, 1-hour; 10 mg/m^3, 8-hour) at Site A6 for the Baseline period (1975, 1976) and 1979.

Season	Averaging Time	Peak Concentration		Second Highest Concentration		Average		Number of Observations		Number of Exceedances of Standard	
		Baseline	1979	Baseline	1979	Baseline	1979	Baseline	1979	Baseline	1979
Winter	1-hour	3.0	0.7	2.2	0.7	0.3	0.1	3,336	1,734	0	0
	8-hour	0.6	0.4	0.5	0.4	0.2	0.1			0	0
Spring	1-hour	0.8	1.8	0.7	0.9	0.1	0.1	3,327	2,112	0	0
	8-hour	0.3	0.4	0.3	0.2	0.1	0.1			0	0
Summer	1-hour	3.0	0.2	2.7	0.2	0.2	0	2,038	1,972	0	0
	8-hour	1.8	0.2	1.7	0.1	0.1	0			0	0
Fall	1-hour	1.2	0.8	1.2	0.7	0.2	0.2	3,545	1,990	0	0
	8-hour	0.3	0.4	0.3	0.4	0.1	0.2			0	0

0.5 mg/m^3 and practically all the readings fell near or below this value.

No diurnal or seasonal variations were observed in the CO levels. Readings were generally near the detection limit of the instrument, 0.1 mg/m^3 (0.1 ppm).

3. Nitrogen Dioxide (NO_2)

Of the nitrogen oxides, only NO_2 has a Federal ambient air quality standard (annual average of 100 μg/m^3). Table 4.2-8 shows the annual averages for both the Baseline and Interim periods. The California standard (for reference) is a one-hour average of 470 μg/m^3. This table also shows the highest, second highest, and average one-hour avarages. Again, activity on the tracts during the first part of the Baseline program could have produced the high values of 100 μg/m^3.

The precision of the instrument is around 20 μg/m^3 and readings are generally below this value and near the lower detection limit of this instrument (5 μg/m^3). The highest one-hour value during 1979 was 30 μg/m^3, recorded during the winter. No seasonal trends are evident.

4. Sulfur Dioxide, SO_2

Table 4.2-9 gives the 1979 and Baseline comparison of the highest, second highest, average and percent exceedance of both the three-hour and twenty-four-hour readings of SO_2. No seasonal or diurnal trend has been evident and most values are near the detection limit of 25 μg/m^3. The highest three-hour SO_2 reading of 94 μg/m^3 was recorded during the fall of 1979. The standard for a three-hour averaging time is 1,300 μg/m^3. The highest 24-hour SO_2 reading was 12 μg/m^3 and was

TABLE 4.2-8. The peak, second highest and average hourly-averaged NO_2 concentrations ($\mu g/m^3$) as well as the number of observations exceeding the California 1-hour standard (470 $\mu g/m^3$) at Site A6 for the Baseline period and 1979.

Season	Peak Concentration		Second Highest Concentration		Average		Number of Observations		Number of Exceedances of Standard	
	Baseline	1979	Baseline	1979	Baseline	1979	Baseline	1979	Baseline	1979
Winter	20	30	20	26	5	4	2,460	1,005	0	0
Spring	20	9	20	9	5	1	3,984	2,087	0	0
Summer	100	8	90	8	15	0	3,600	2,144	0	0
Fall	100	24	80	23	10	1	3,996	1,792	0	0
Annual	-	-	-	-	9	2	2	1	0	0

TABLE 4.2-9. The peak, second highest, and average hourly averaged SO_2 concentrations ($\mu g/m^3$, as well as the number of observations exceeding the 3-hour standard (1300 $\mu g/m^3$), 24-hour standard (365 $\mu g/m^3$) at Site A6 during the Baseline period (1975, 1976) and 1979.

Season	Averaging Time	Peak Concentration		Second Highest Concentration		Average		Number of Observations		Number of Exceedances of Standard	
		Baseline	1979	Baseline	1979	Baseline	1979	Baseline	1979	Baseline	1979
Winter	3-hour	10	8	5	5	3	2	1,144	688	0	0
	24-hour	5	3	5	3	3	1	143	71	0	0
Spring	3-hour	10	5	10	4	3	2	1,216	701	0	0
	24-hour	5	2	5	1	3	0	152	92	0	0
Summer	3-hour	10	11	10	6	4	2	1,136	729	0	0
	24-hour	5	6	5	5	3	2	142	92	0	0
Fall	3-hour	5	94	5	57	3	2	1,376	708	0	0
	24-hour	5	12	5	7	3	1	172	91	0	0

also recorded during the fall 1979. Again, this reading is well below the 24-hour standard of 365 $\mu g/m^3$. The annual average on the tracts is from 1 $\mu g/m^3$ to 2 $\mu g/m^3$ as compared to the annual standard of 80 $\mu g/m^3$. Most values have been near the detection limit of the instrument (25 $\mu g/m^3$).

The isolated higher than normal values in the fall were valid readings and were probably due to local small-scale fuel burning activities, although no corresponding increases in NO_x or CO were detected. Those readings, however, were inconsequential when compared with the ambient air quality standard.

5. Hydrogen Sulfide (H_2S)

Since there are no Federal standards for H_2S, a reference for interpreting the data is the California one-hour standard of 42 $\mu g/m^3$.

Most readings are below the detection limit of 10 $\mu g/m^3$ (0.008 ppb) of the instrument. Table 4.2-10 gives the comparisons of the baseline and interim periods with highest, second highest, average and percent of exceedances of the California standard. During the initial time of the baseline period some values were higher, probably locally-induced by tract activity.

No diurnal or seasonal trends were evident. The highest value of 30 $\mu g/m^3$ was recorded during the beginning of the baseline period when tract activity was high. The highest hourly value in 1979 was 8 $\mu g/m^3$ during the summer.

TABLE 4.2-10. The peak, second highest, and average hourly-averaged H_2S concentrations ($\mu g/m^3$), as well as the number of observations exceeding 42 $\mu g/m^3$ at Site A6 for the Baseline period (1975, 1976) and 1979.

Season	Peak Concentration		Second Highest Concentration		Average		Number of Observations		Number of Exceedances >42 $\mu g/m^3$	
	Baseline	1979	Baseline	1979	Baseline	1979	Baseline	1979	Baseline	1979
Winter	20	3	20	3	5	0	1,320	2,065	0	0
Spring	30	3	30	1	10	0	1,680	2,158	0	0
Summer	20	8	15	1	5	0	1,440	2,193	0	0
Fall	5	1	0	1	0	0	2,040	2,142	0	0

6. Non-Methane Hydrocarbon (NMHC)

The precision of the Beckman Instruments' gas chromatograph for the analysis of hydrocarbons is 0.1 ppm (70 $\mu g/m^3$) for THC (total hydrocarbons) and 0.1 ppm for CH_4 (methane). To obtain NMHC, the CH_4 reading is subtracted from the THC reading. This compounds an error to about 0.2 ppm (130 $\mu g/m^3$), and considerably larger errors are possible on a sample-to-sample basis. Even if perfectly calaborated, the instrumentation precision is inconsistent with the NMHC standard of 160 $\mu g/m^3$.

However, the EPA-prescribed reference method for measuring non-methane hydrocarbons is by flame ionization detection and gas chromatography (exactly those used in the Beckman instrument). Thus, the measurement procedures used during the program are the best available. This inconsistency between the ambient air quality standard and the instrumentation technique is recognized by the EPA. In early 1978, the EPA issued a letter discouraging the monitoring of NMHC on oil shale lease tracts. Following EPA's suggestion, and with the approval of the Area Oil Shale Supervisor, total hydrocarbons (THC) and methane (CH_4) were monitored in 1979, but NMHC values were not determined and are not reported.

Suspended Particulate (TSP)

Particulate concentrations are monitored by high volume samplers which sample over a period of 24 hours once every six days. The size of the particulate matter collected by the samplers ranges from below 1 μm to 100 μm.

Table 4.2-11 gives the geometric mean, standard geometric deviation, maximm and minimum of the total suspended particulate concentrations in $\mu g/m^3$ at Site A-6. The Baseline period and 1979 are shown by season.

The geometric mean given can be considered to correspond to the maximum concentration expected at a 50% frequency because particulate concentrations are generally log-normally distributed. The geometric mean of particulate concentrations during 1979 range from 8.1 $\mu g/m^3$ during the spring to 19.0 $\mu g/m^3$ during the summer.

None of the recorded values exceeded federal or state standards, which are presented in Table 4.2-12. The most stringent short-term standard is the National Secondary Standard, which sets the upper limit at 150 $\mu g/m^3$, averaged over 24 hours; this is not to be exceeded more than once a year.

Summary of Background Averages

Table 4.2-13 gives the annual averages for the pollutants monitored on the tracts from 1975 and 1976 (Baseline) through 1979 (Interim). Generally, the values were slightly lower during the last three years. The values recorded during the Interim period are more representative of true background conditions since during this time activities on the tracts were at a minimum.

The ozone increase for 1979 was covered in a previous section. The continuous decrease in TSP from the Baseline period corresponds to the decrease in annual average wind speeds on the tracts at Site A-6 -- 1975, 4.0 m/s; 1976, 4.2 m/s; 1977, 3.1 m/s; 1978, 2.8 m/s; and 1979, 2.9 m/s.

TABLE 4.2-11. Geometric means, standard geometric deviations, and maximum and minimum of particulate concentrations ($\mu g/m^3$) for Baseline period (1975, 1976), and Interim period (1979) at Site A6.

	Season	Baseline	1979
Geometric mean	Winter	14.2*	9.2
	Spring	17.2	8.1
	Summer	37.0	19.0
	Fall	27.2	16.4
Standard Geometric Deviation	Winter	2.6*	1.6
	Spring	1.9	2.7
	Summer	1.4	1.7
	Fall	2.0	3.4
Maximum	Winter	51.9*	19.6
	Spring	42.0	34.3
	Summer	74.7	35.8
	Fall	101.2	52.9
Minimum	Winter	3.5*	4.7
	Spring	4.9	1.6
	Summer	18.7	6.5
	Fall	4.9	0.5
Geometric mean	Annual	24.0	12.5
Standard Geometric Deviation	Annual	2.5	2.2

* 1976 only, insufficient data for 1975.

TABLE 4.2-12. Federal and Utah state ambient air quality standards for particulate matter ($\mu g/m^3$).

Pollutant	Averaging Time	Standards	
		Primary	Secondary
Suspended Particulate Matter	Annual Geometric Mean	75	60
	24-hour	260	150

TABLE 4.2-13. The annual averages ($\mu g/m^3$) for the gaseous pollutants and annual geometric mean for TSP during the entire period of Baseline (1975, 1976) and Interim (1977, 1978, 1979 periods).

Pollutant	Annual Averages				
	Baseline		Interim		
	1975	1976	1977	1978	1979
O_3	75	63	61	58	74
CO (mg/m^3)	.3	.2	.2	.1	.1
NO_2	6	5	0	1	2
SO_2	3	0	0	3	1
H_2S	10	3	0	1	0
TSP	24.5	23.5	22.2	15.0	12.5

4.2.2 Meteorological Monitoring Program

Meteorological data collection in the Interim Monioring Program was also implemented on January 16, 1977. Monitoring equipment at the four sites during 1979 are identical to that used during the two-year Baseline period.

4.2.2.1 Objectives. The objectives of continuing the meteorological measurements in the Interim Monitoring Program are to extend the meteorological data base, determine trends, and to provide verification of Baseline data for future air pollutant dispersion modeling work.

4.2.2.2 Methods. The meteorological parameters monitored are shown in Table 4.2-14. Meteorological data are collected continuously and recorded on digital punch tapes every six minutes. Strip charts are also used at Sites A-4 and A-6 for a backup record.

Table 4.2-15 lists the meteorological monitoring equipment used.

In accordance with the Quality Assurance Plan (AeroVironment Inc., 1978) the quality assurance procedures for meteorological instruments were carried out during this period. For some meteorological instruments, off-site calibration is done annually and calibration checks are performed quarterly.

4.2.2.3 Present Status and Plans for 1980. The extent of the data collected during 1979 is tabulated in Table 4.2-16. This table lists the percentage of hours that data was collected for each meteorological parameter. No changes in meteorological monitoring programs are planned for 1980.

TABLE 4.2-14. Meteorological parameters monitored during lease suspension period.

Parameter	Station			
	A4	A6	A11	A13
Meteorology				
WS/WD - 10 m	X	X	X	X
WS/WD - 20 m		X		
WS/WD - 30 m		X		
T - 10 m	X	X	X	X
ΔT - 10-30 m		X		
σ_θ - 10 m	X			
σ_θ - 30 m		X		
σ_w - 10 m	X			
σ_w - 30 m		X		
Net solar radiation		X		
Dew point		X		
Relative humidity		X		
Barometric pressure		X		

TABLE 4.2-15. Meteorological monitoring equipment.

Parameters	Instrument	Location
Wind speed and direction	Meteorology Research Inc. Model 1022 anemometer	A6, (10, 20 and 30m) A4 (10m)
Wind speed, direction, and temperature	Meteorology Research Inc. 1071 mechanical weather station	A11 (10m) A13 (10m)
Wind variance	Meteorology Research Inc., R. M. Young anemometer, and AeroVironment Inc. sigma meter	A6 (10 and 30m) A4 (10m)
Temperature and lapse rate	Meteorology Research Inc. thermistors with R. M. Young shield	A6 (10 and 30m) A4 (10m)
Dew point	WeatherMeasure Inc. Model H321S hygrograph	A6

TABLE 2.4-16. Percentage of time monitoring was performed for meteorological parameters during period 1 January - 31 December 1979.

Component	Number of Stations	Percentage
Wind (10m)	4	100
Wind (20m)	1	100
Wind (30m)	1	100
Temperature (10m)	4	99
Temperature (30-10m)	1	100
Relative Humidity (10m)	1	80

4.2.2.4 Data Summary. Before discussing the details of the transport and dispersion characteristics of the atmosphere over the Ua/Ub Tracts, it would be appropriate to summarize the major weather systems that affect the large scale movement of air masses over the area.

The horizontal transport of an air mass is a consequence of large-scale differences in air pressure. The determining factor in Utah's weather during the winter months is the location and strength of the Intermountain Region High Pressure Cell. Figure 4.2-7a shows the normal Janaury sea level pressure and temperature. Storm tracks during mid-winter tend to pass north through Montana and through southern Utah. After February, storm tracks became more prevalent over northern Utah as the strength of the Basin High wanes. Precipitation is highest during the spring months.

During the summer months (Figure 4.2-7b), the pressure is lower and sporadic moisture from the Gulf of Mexico brings periods of scattered thundershower activity. Beginning September, the storm fronts from the north increase but are interspersed with many periods of clear weather when high pressure builds up in the Intermountain Basin.

The Interim Program meteorological data for 1979 is presented in the following sections and compared quantitatively with the Baseline (1975-1976) Program data to determine any significant changes.

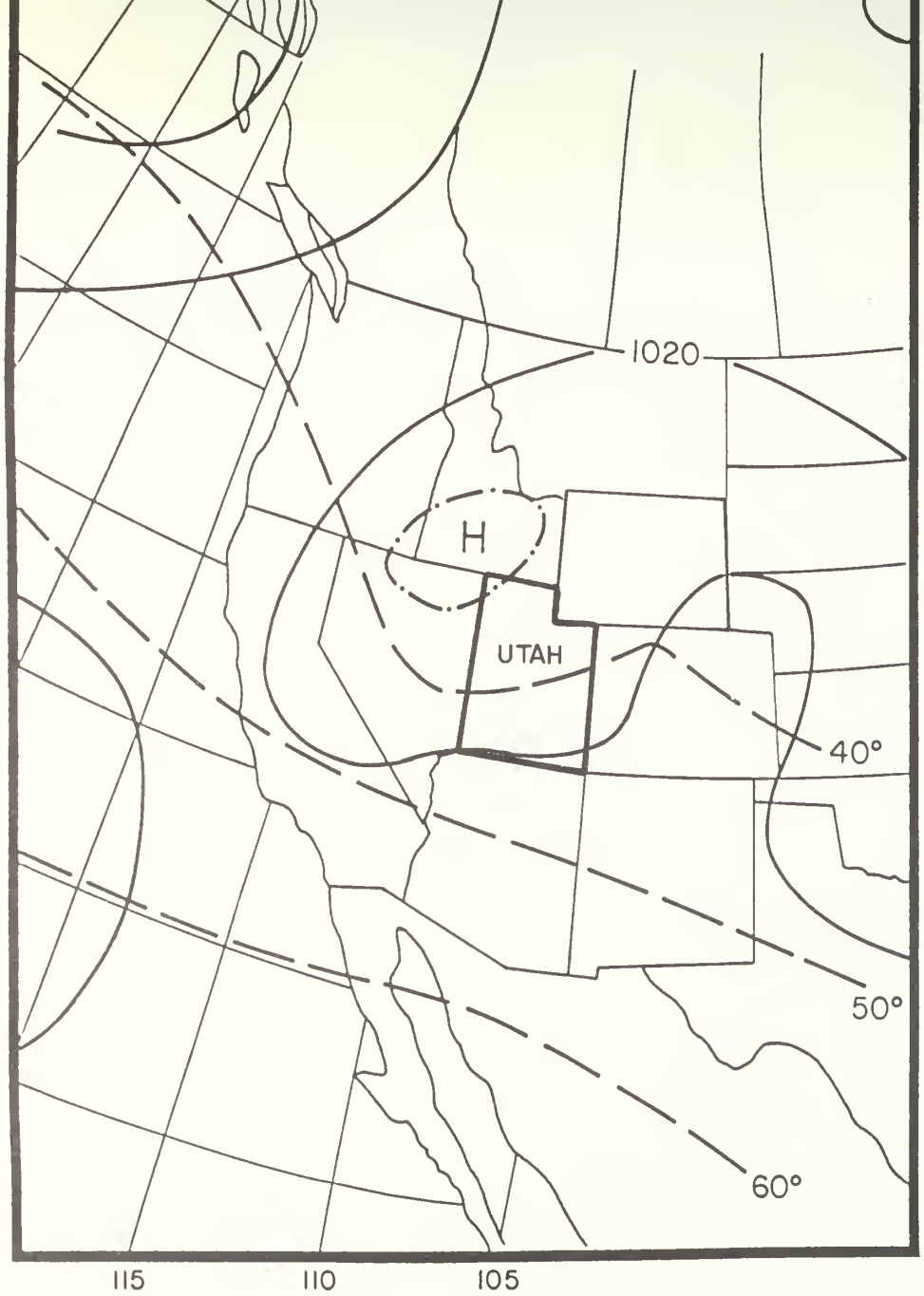


FIGURE 4.2-7a Normal January sea level pressure in mb(solid lines) and temperature in ^{o}F (dashed lines).

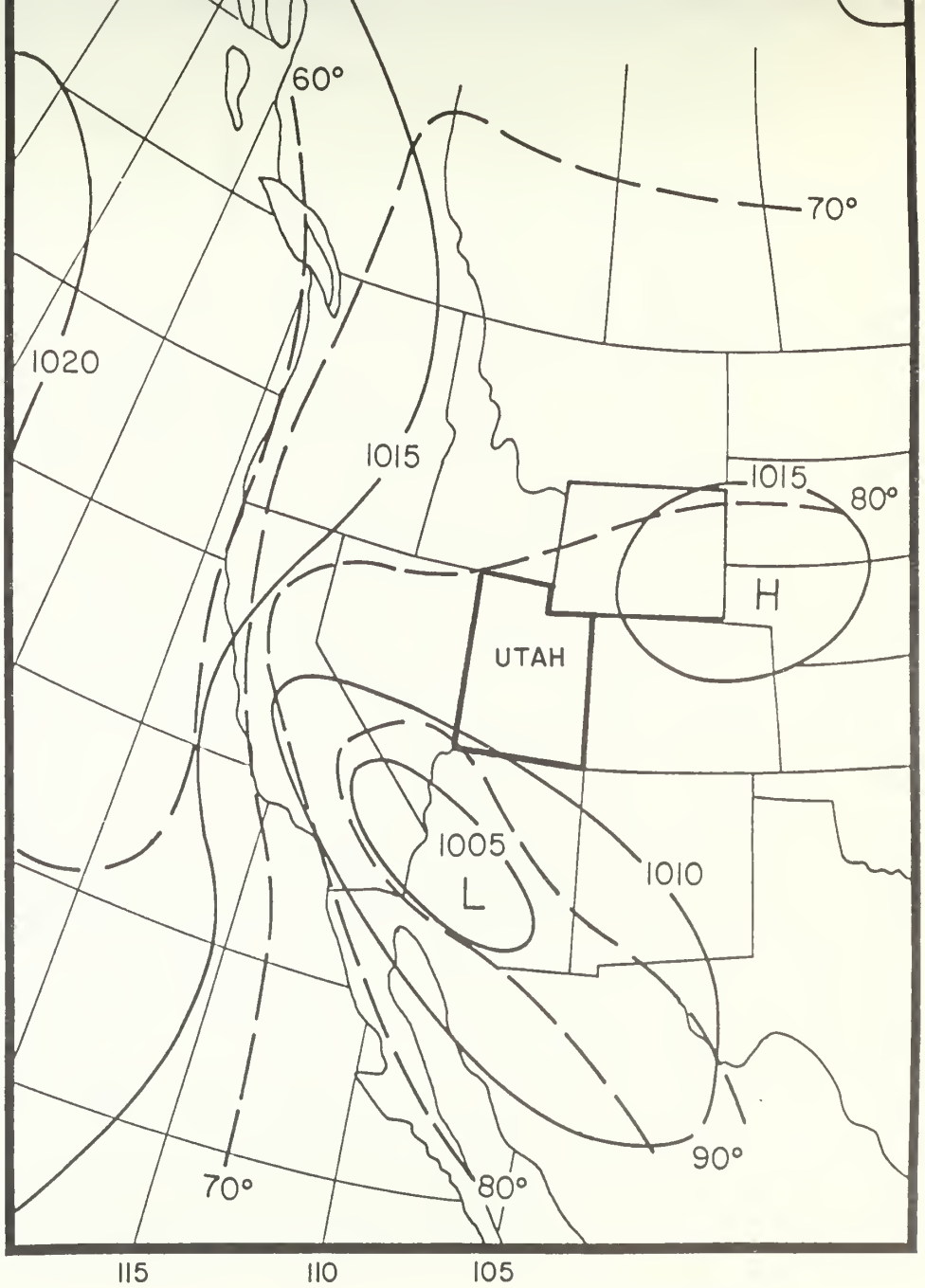


FIGURE 4.2-7b Normal July sea level pressure in mb (solid lines) and temperature in ^{o}F (dashed lines).

Source: U.S. Weather Bureau, 1952.

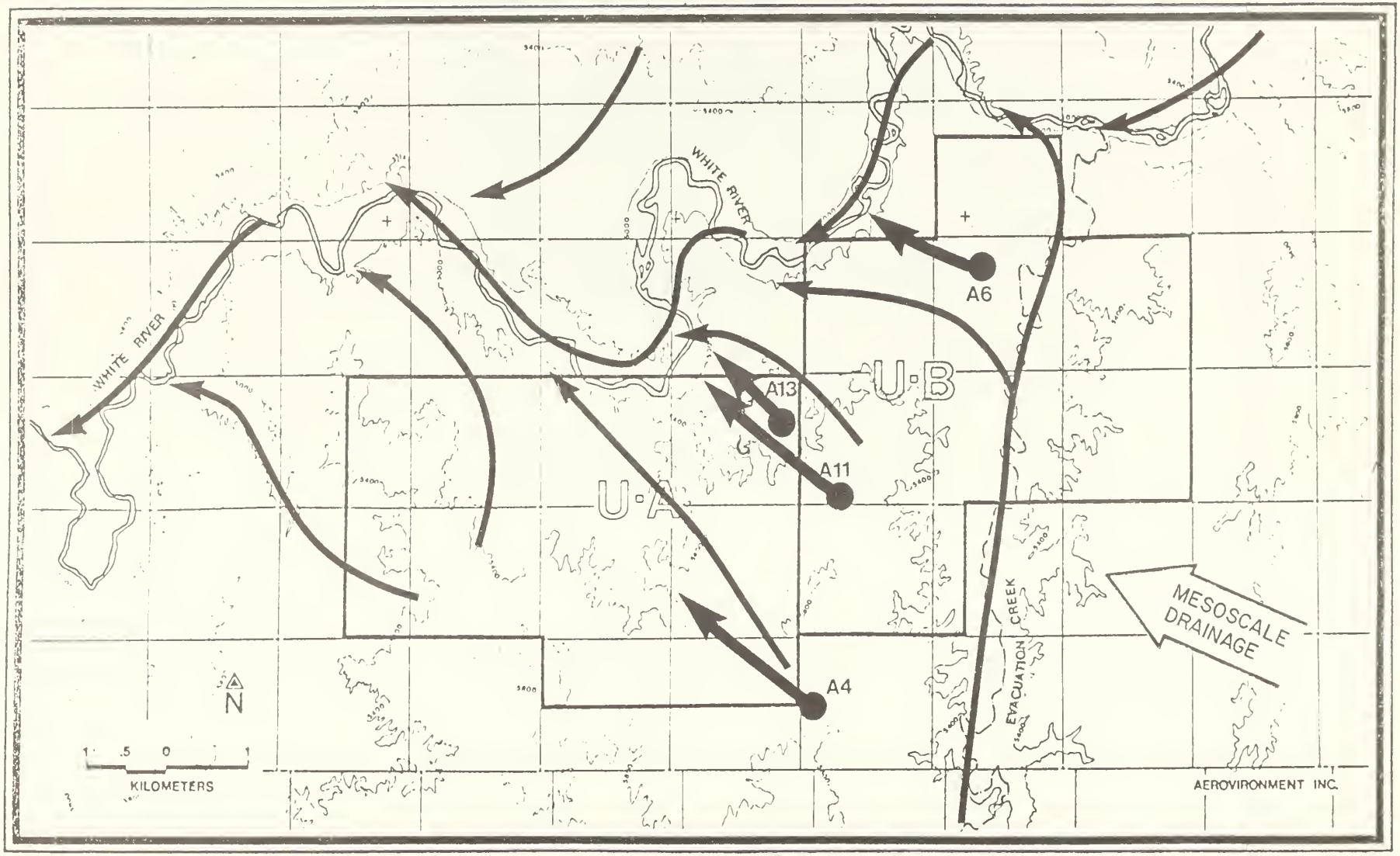
Surface Flow

As usual, the rugged terrain features in the area complicated the airflow pattern. Table 4.2-17 shows the prevailing wind direction and wind speed by month for four sites. Spatial variation in wind speed on the tracts was also observed through the Baseline period. Generally, nighttime drainage flow is prevalent throughout the year. Figure 4.2-8 shows the typical airflow streamlines for the early morning drainage pattern. The solid arrows on this figure are wind vectors at the monitoring sites, and the longer lines are estimated flow streamlines. The large open arrow depicts the mesoscale flow direction in the greater White River drainage basin. The drainage pattern does not deviate significantly throughout the year. This figure was prepared from averaged wind observations in 1979 at the four sites, plus knowledge of the wind flow pattern as presented in reports prepared for the Baseline period. The drainage flow is always from higher to lower terrain, as noted during the Baseline period.

Figure 4.2-9 shows an upslope pattern that is transitional between drainage and synoptic flow. The surface-based inversion that results from strong radiative cooling begins to lose some of its strength shortly after sunrise. As the morning progresses, the heat gained by the surface from solar radiation exceeds that lost by terrestrial radiation and the soil temperature rises, warming the air above. This creates a pressure difference resulting in upslope flow. This pattern is transitional and generally lasts less than an hour, but is important to understanding of dispersion of pollutants since plume fumigation would occur under this condition. Because of its brevity, this pattern is lost in the hourly-average wind direction. This pattern begins earlier during the summer months than during the winter when the sun rises later.

TABLE 4.2-17. Prevailing wind direction/speed (in m/s) on the tracts during 1979.

Month	Site			
	A4	A6	A11	A13
Jan	W/1.6	WSW/1.3	SE/1.6	W/0.9
Feb	W/1.8	WSW/1.3	NW/1.8	W/1.1
Mar	W/2.5	WSW/2.0	SE/2.2	W/1.6
Apr	W/3.4	SE/3.4	SSE/3.4	S/2.5
May	W/3.1	SE/3.5	SE/3.1	SE/2.5
Jun	W/3.4	ESE/3.8	SE/3.6	WNW/2.9
Jul	WNW/2.7	ESE/3.4	SSE/3.4	SE/2.7
Aug	SE/2.5	ESE/3.1	SSE/3.1	SE/2.7
Sep	WNW/2.5	ESE/2.9	SSE/3.1	S/2.0
Oct	WNW/2.0	ESE/ -	SE/2.7	SSW/1.8
Nov	W/1.6	ESE/ -	SE/2.2	-/-
Dec	WSW/ -	ESE/1.8	SE/1.8	S/0.9
Annual	W/2.5	ESE/2.7	SE/2.7	VAR/1.8

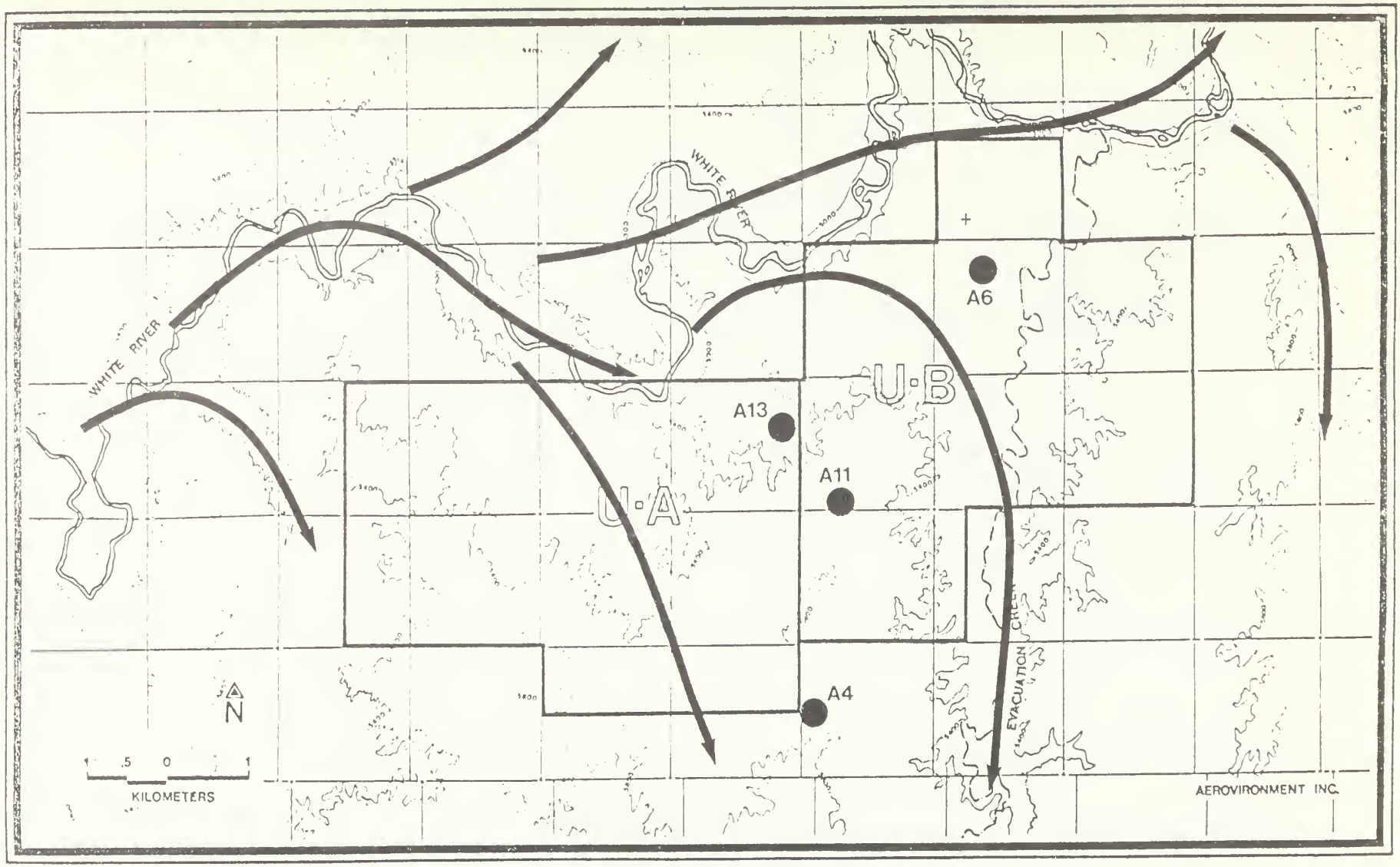


2 m/sec

Wind Vector

Streamline

FIGURE 4.2-8. Typical drainage flow pattern on tracts Ua and Ub during the early morning hours - 1979.



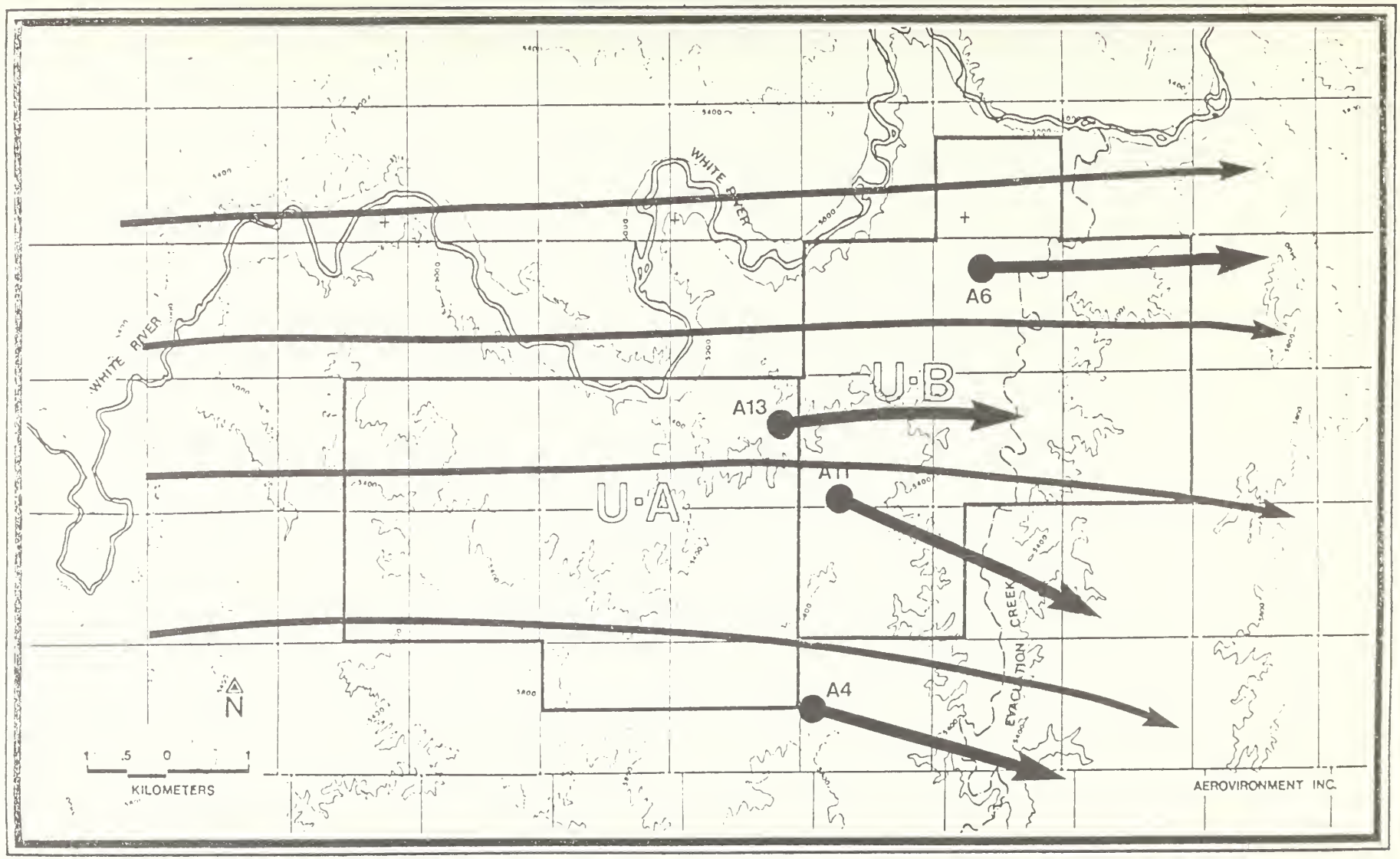
Streamline

FIGURE 4.2-9. Typical airflow pattern on tracts Ua and Ub during the transitional period - 1979.

Figure 4.2-10 shows afternoon streamlines on the tracts during 1979. Very little directional difference is noted except the average speeds are higher during the summer. No significant difference from the Baseline period is noted. This is the average synoptically-induced flow that is encountered in this portion of Utah throughout the year.

Figures 4.2-11 and 4.2-12 give the average hourly wind speeds for January and July. The July 1979 and Baseline speeds are practically the same during the afternoon. January 1979 wind speeds were much lower than the Baseline averages. The month of January 1979 was unique over the tracts because almost the entire month was under weak polar westerlies. Strong, moist Pacific frontal systems moved into Utah without support by strong upper level winds. Consequently, many frontal systems would stagnate over Utah.

Figures 4.2-13 through 4.2-16 show the directional wind roses at the monitoring stations on the tracts using the mid-month of the four seasons (January, April, July, and October 1979). Although individual months may show different prevailing directions, ESE has been the most prevailing direction at Site A-6 throughout the Baseline and Interim periods. The frequent occurrence of the ESE wind is a direct result of the drainage flow that exists at Site A-6.



2 m/sec

Wind Vector

Streamline

FIGURE 4.2-10 Typical synoptic airflow pattern on tracts Ua and Ub during the afternoon - 1979.

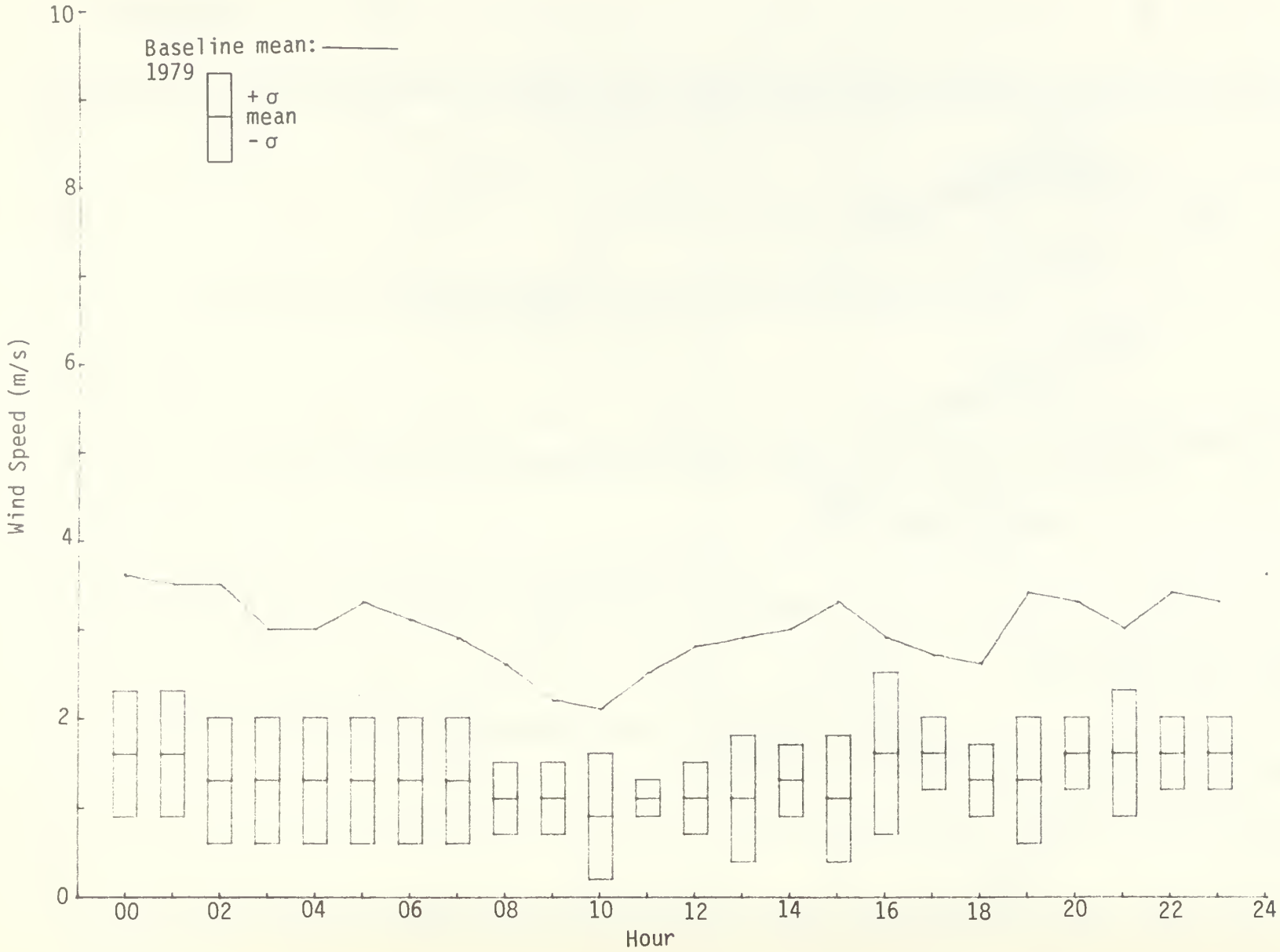


FIGURE 4.2-11. Diurnal variation of mean wind speeds and their standard deviations during January 1979 compared to the Baseline means at Site A6.

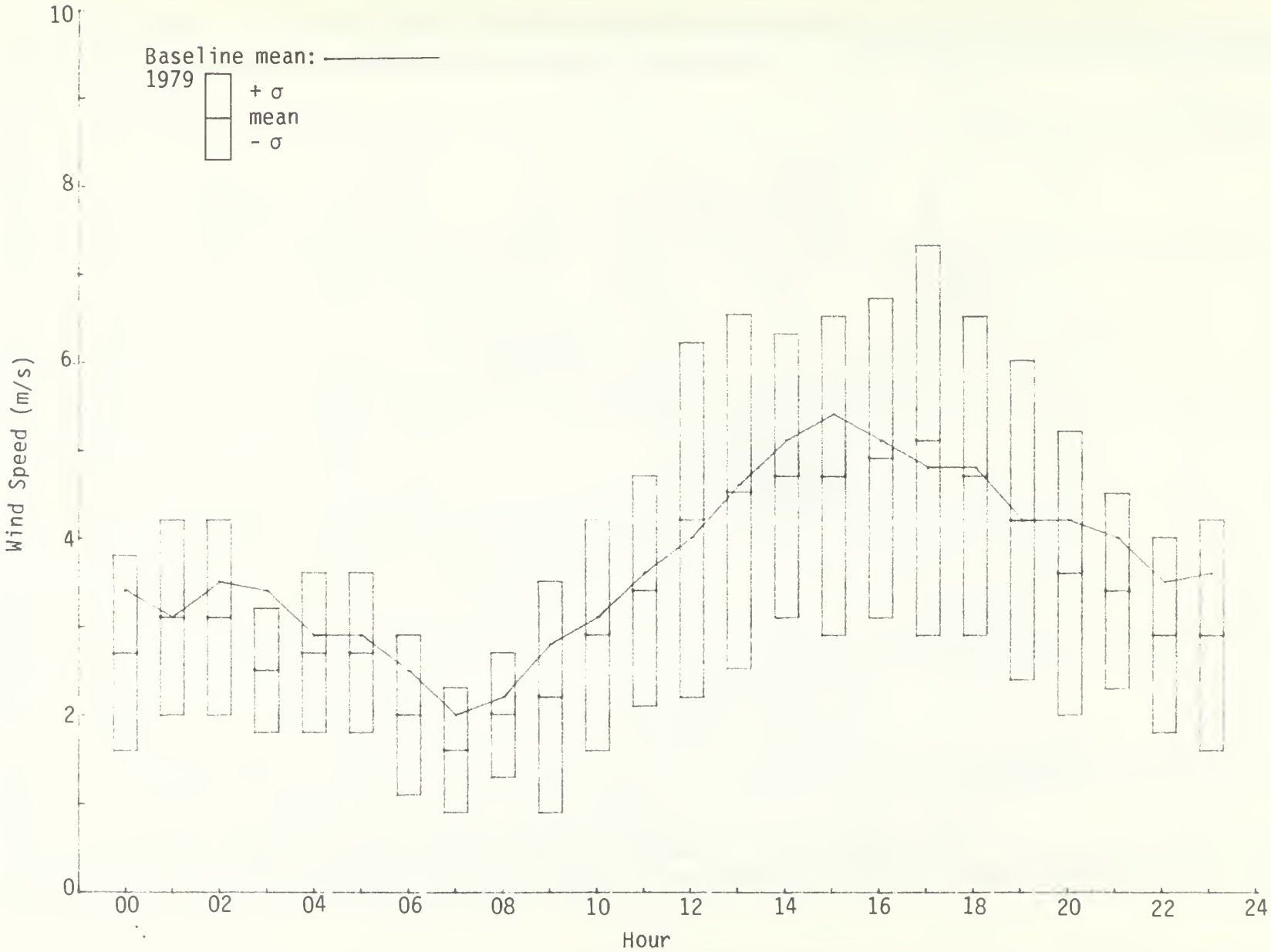
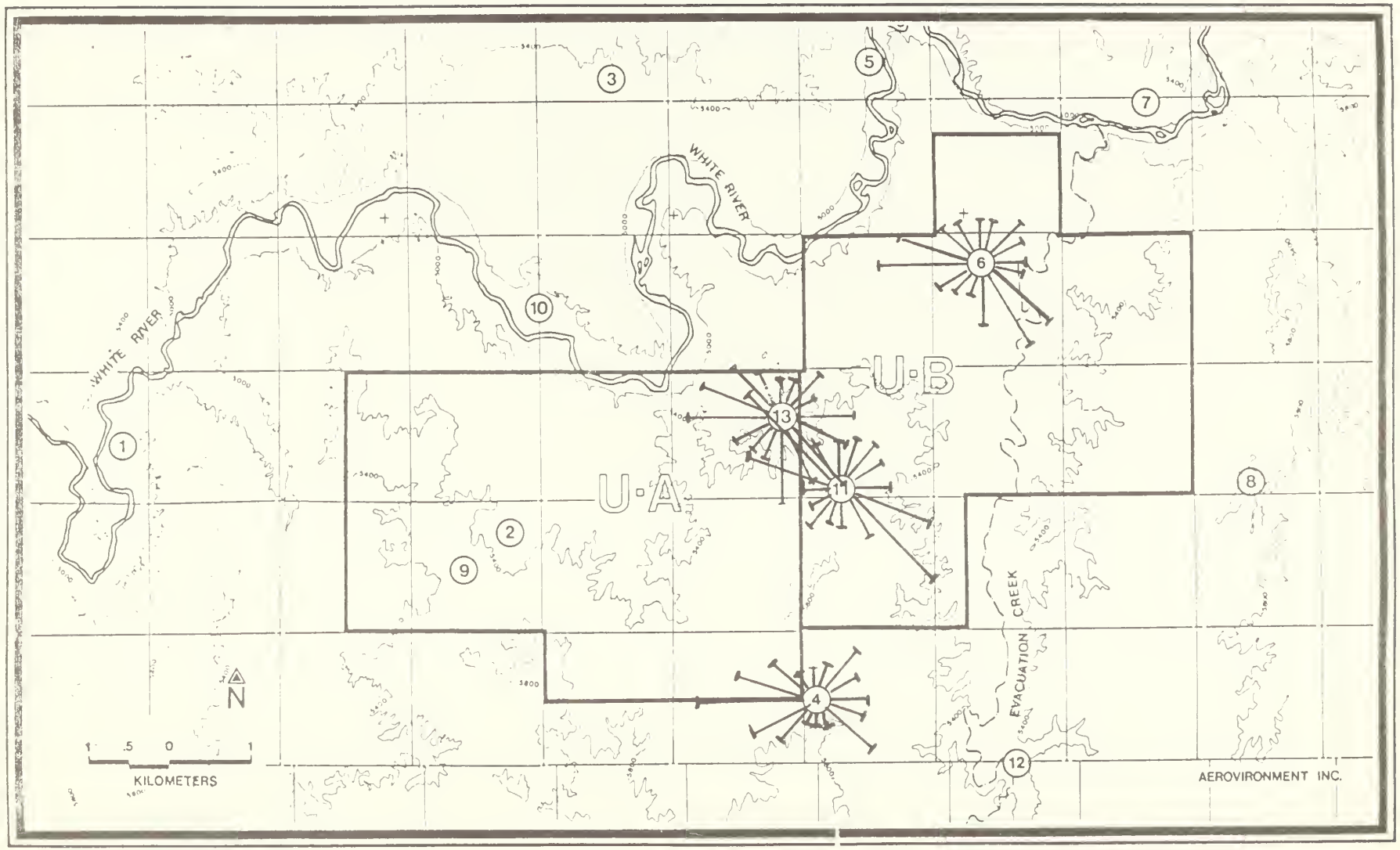


FIGURE 4.2-12 Diurnal variation of mean wind speeds and their standard deviations during July 1979 compared to the Baseline means at Site A6.



0 25
0/0

FIGURE 4.2-13 Directional wind roses at the monitoring stations on the tracts for January 1979. The length of each bar represents the frequency of winds from the direction towards which the bar points.

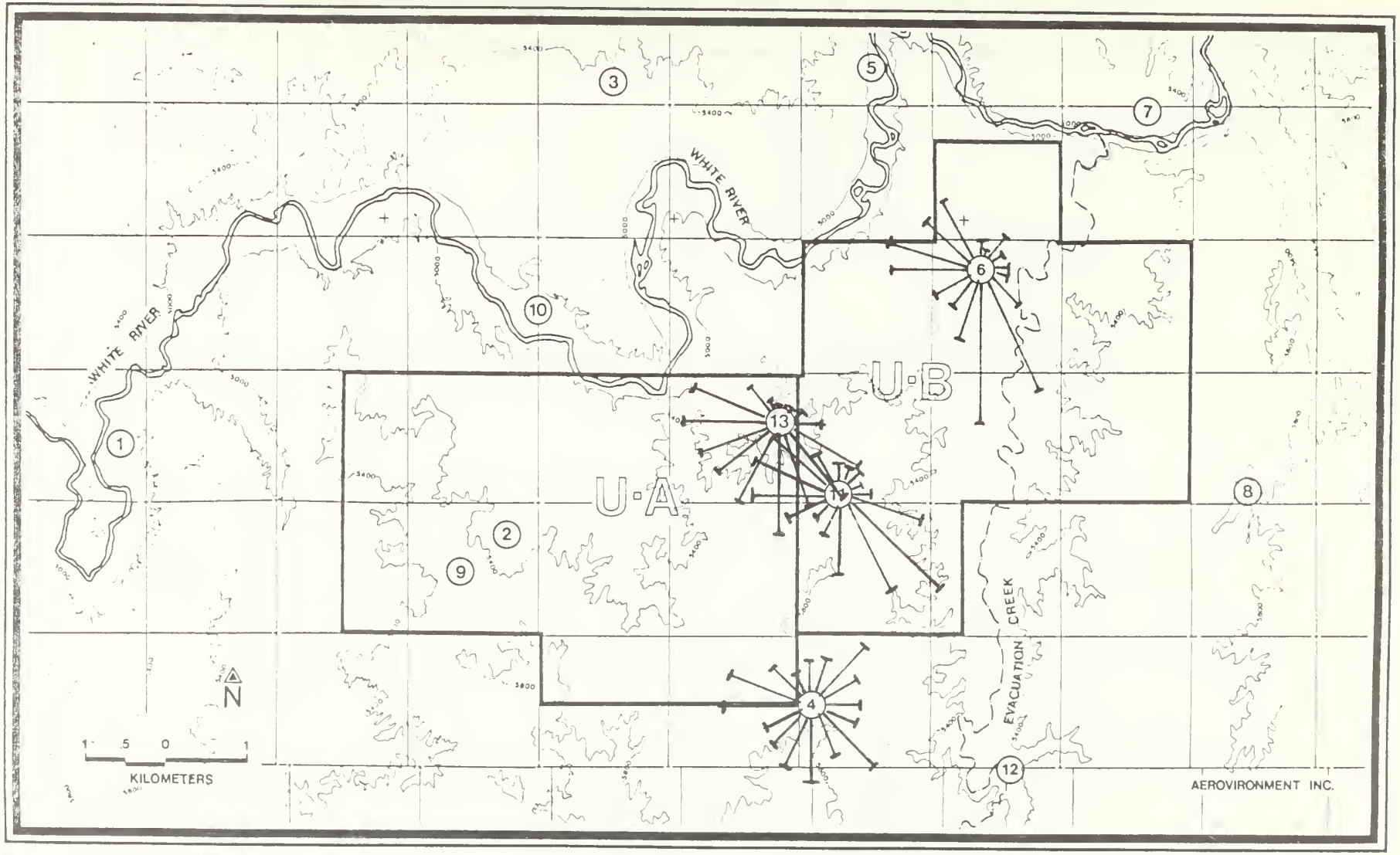


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FIGURE 4.2-14. Directional wind roses at the monitoring stations on the tracts for April 1979. The length of each bar represents the frequency of winds from the direction towards which the bar points.

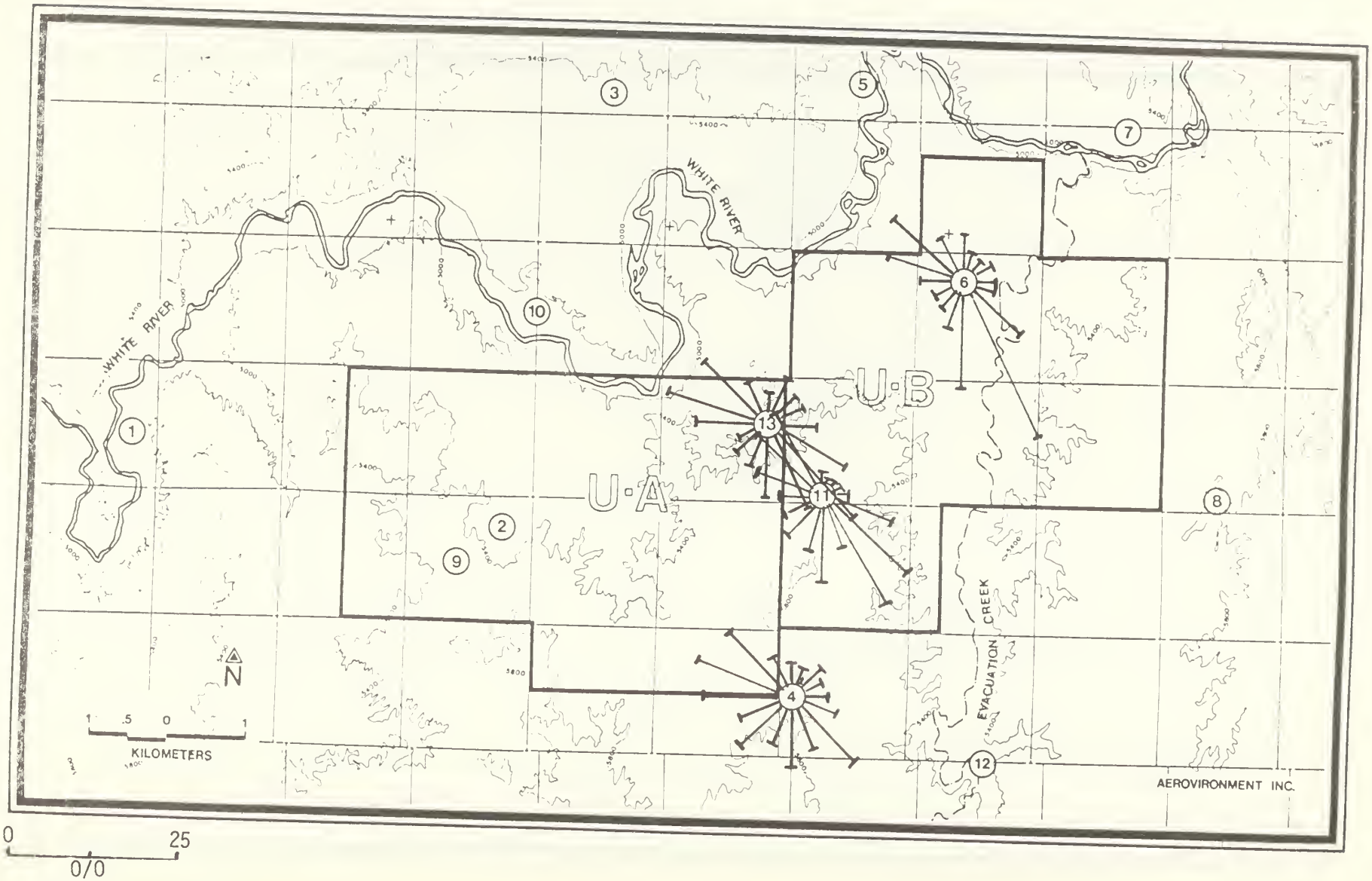

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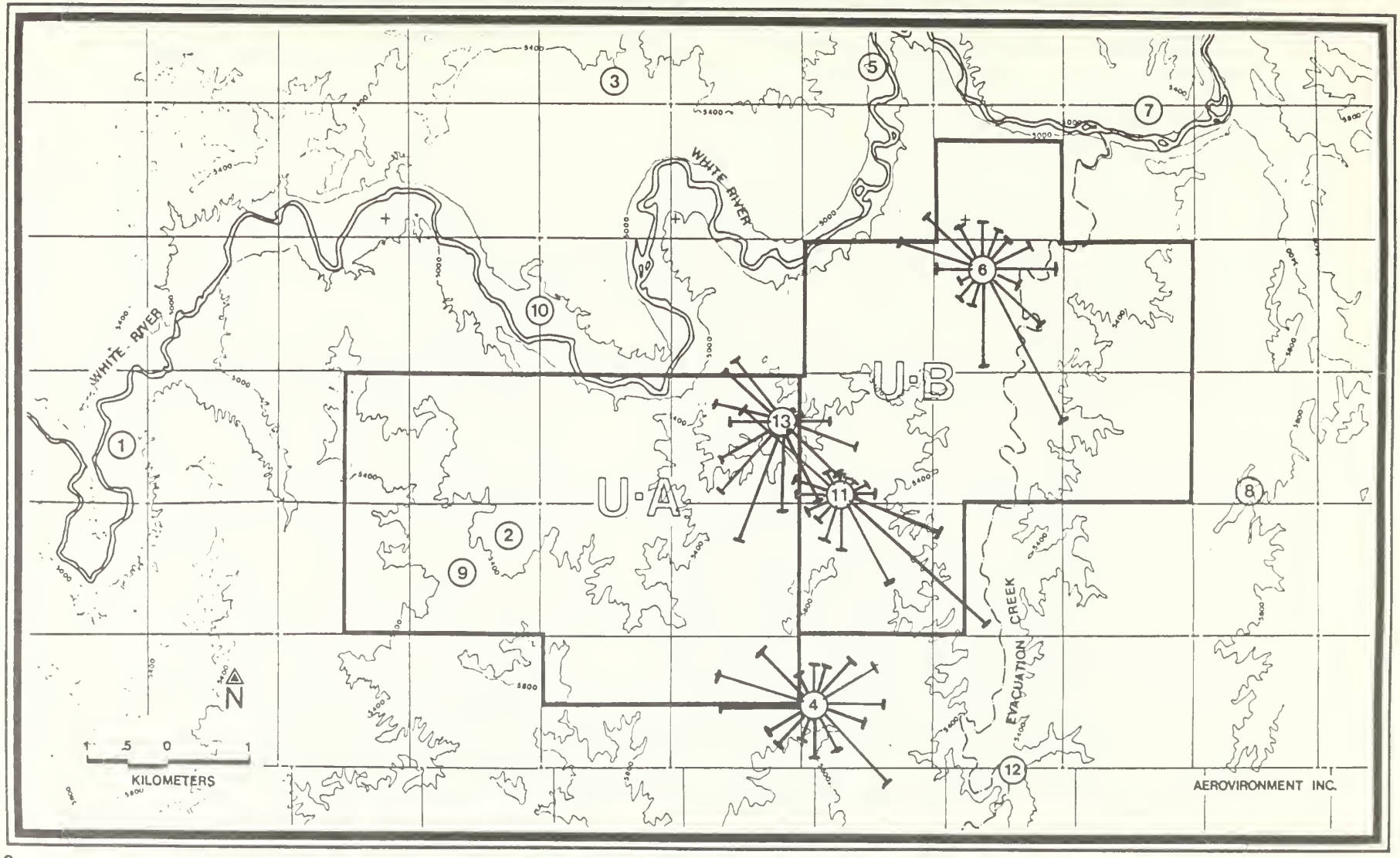
FIGURE 4.2-15. Directional wind roses at the monitoring stations on the tracts for July 1979. The length of each bar represents the frequency of winds from the direction towards which the bar points.



0 25
0/0

FIGURE 4.2-16. Directional wind roses at the monitoring stations on the tracts for October 1979. The length of each bar represents the frequency of winds from the direction towards which the bar points.

Temperature

Figure 4.2-17 presents the diurnal variation in temperature and standard deviation for January and July 1979 at Site A-6. Superimposed on this are the average Baseline values for a comparison. The daily maximum temperature was generally observed between 1400 and 1600 MST, while the daily minimum was observed between 0400 and 0700 MST. The average temperatures were -15° C for January 1979 and 22° C for July 1979. These are shown in Figure 4.2-18 along with the maximum, mean, and minimum for each month in 1979 as compared to the maximum, mean, and minimum for the Baseline period. During January 1979, the extreme coldness is reflected by departure from the Baseline averages. July 1979 compared fairly well with the Baseline period. The highest July temperature observed was 36° C during July 1976 (Baseline period) and August 1979. The lowest temperature observed was -30° C during January 1979.

Relative Humidity

The diurnal variation of relative humidity is approximately the reciprocal of temperature, indicating that the amount of moisture in the air remains fairly constant during the day on the tracts. Figures 4.2-19 and 4.2-20 show the diurnal trend of the average and standard deviations for a winter month (January 1979) and summer month (July 1979). The storminess of January 1979, with associated moisture is reflected by the high relative humidity values compared to the Baseline. July 1979 was only slightly less humid than the Baseline average. The air is drier in summer than in the winter. The highest average readings are found in winter from 0400 through 0800 MST. The lowest values are found during summer afternoons between 1400 and 1600 MST.

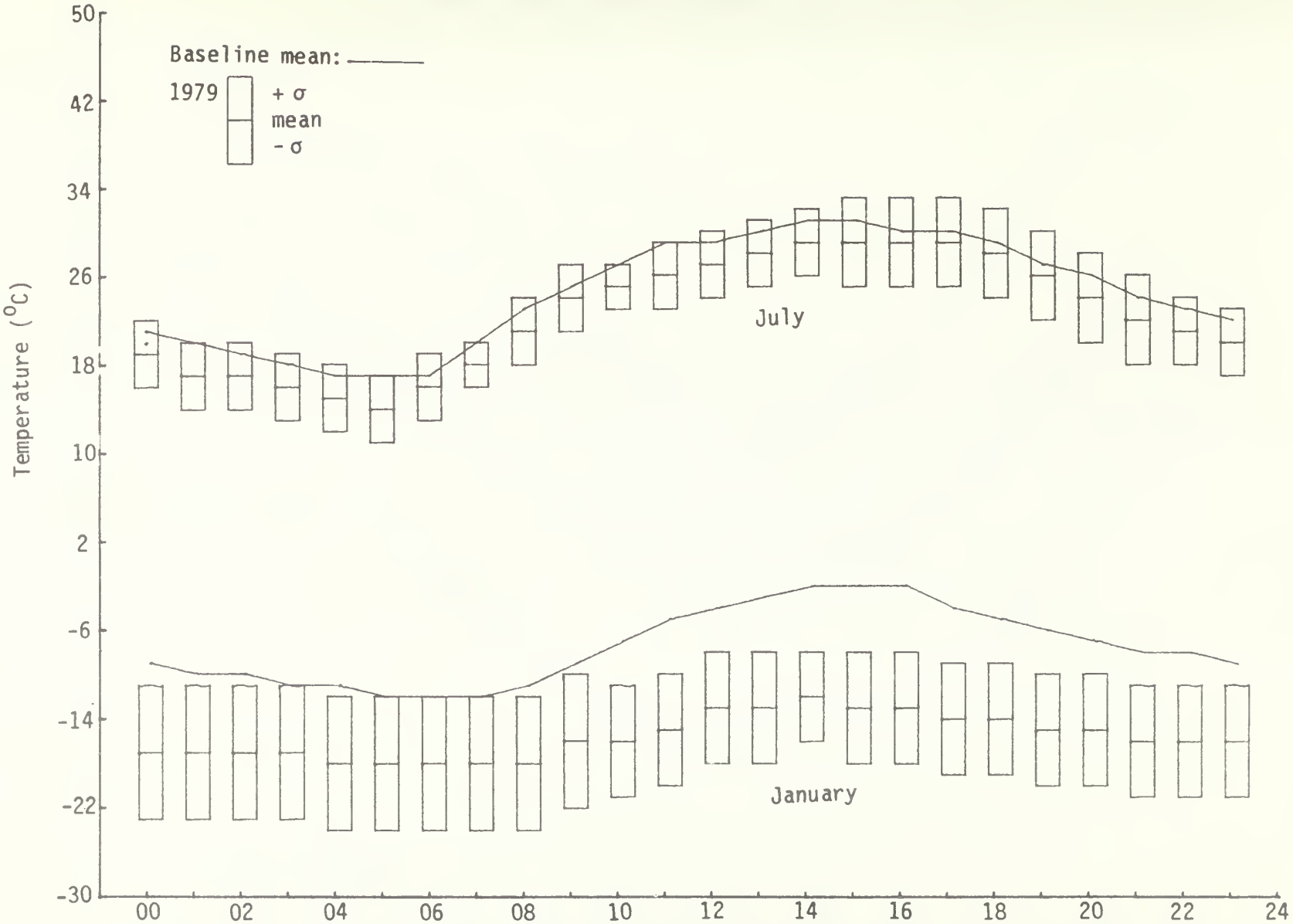


FIGURE 4.2-17. Diurnal variation of mean temperatures and their standard deviations compared to Baseline means at Site A6 during January and July 1979.

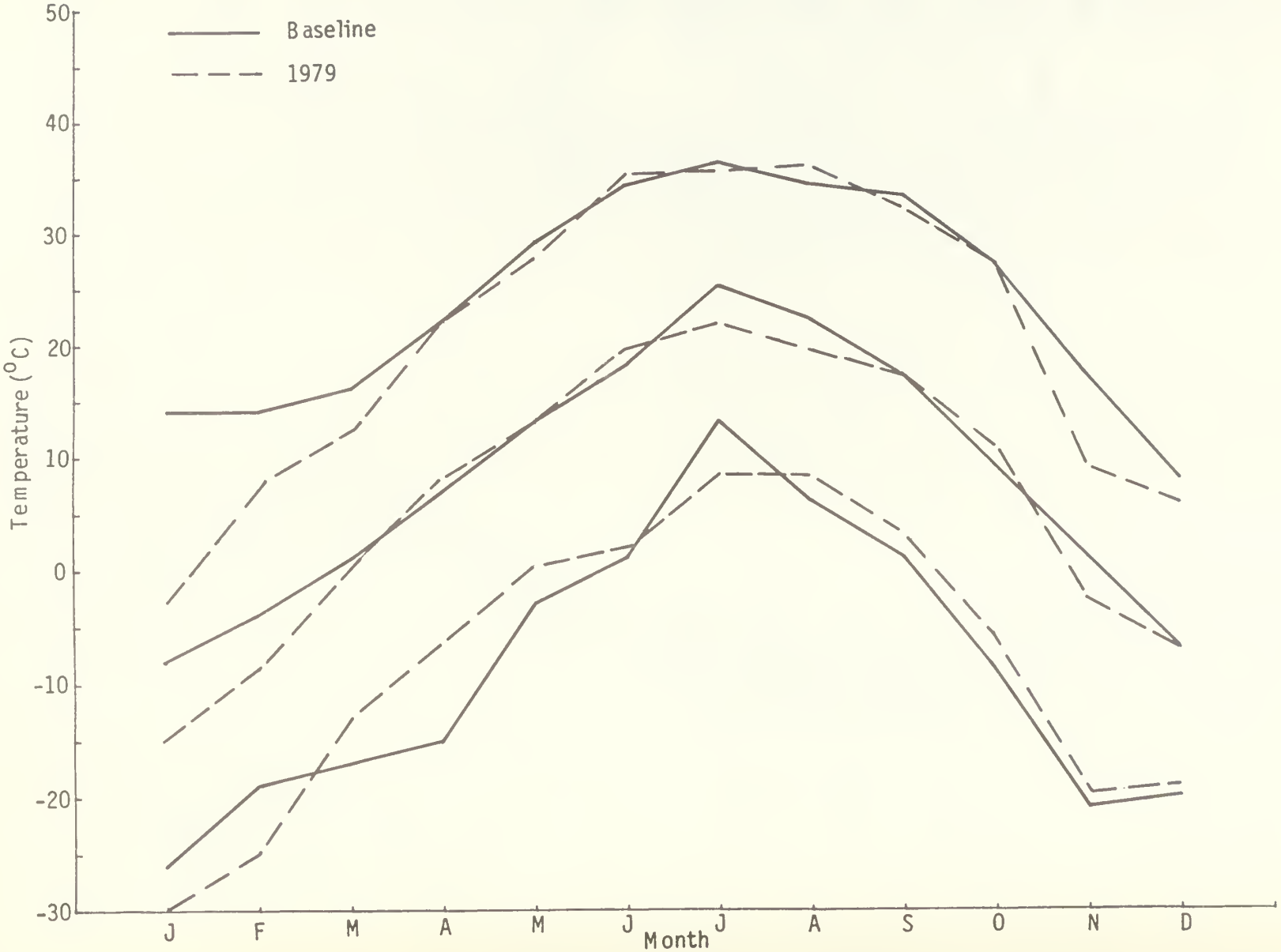


FIGURE 4.2-18. Monthly mean, maximum, and minimum temperatures at Site A6 during 1979 (dashed); compared to Baseline (solid).

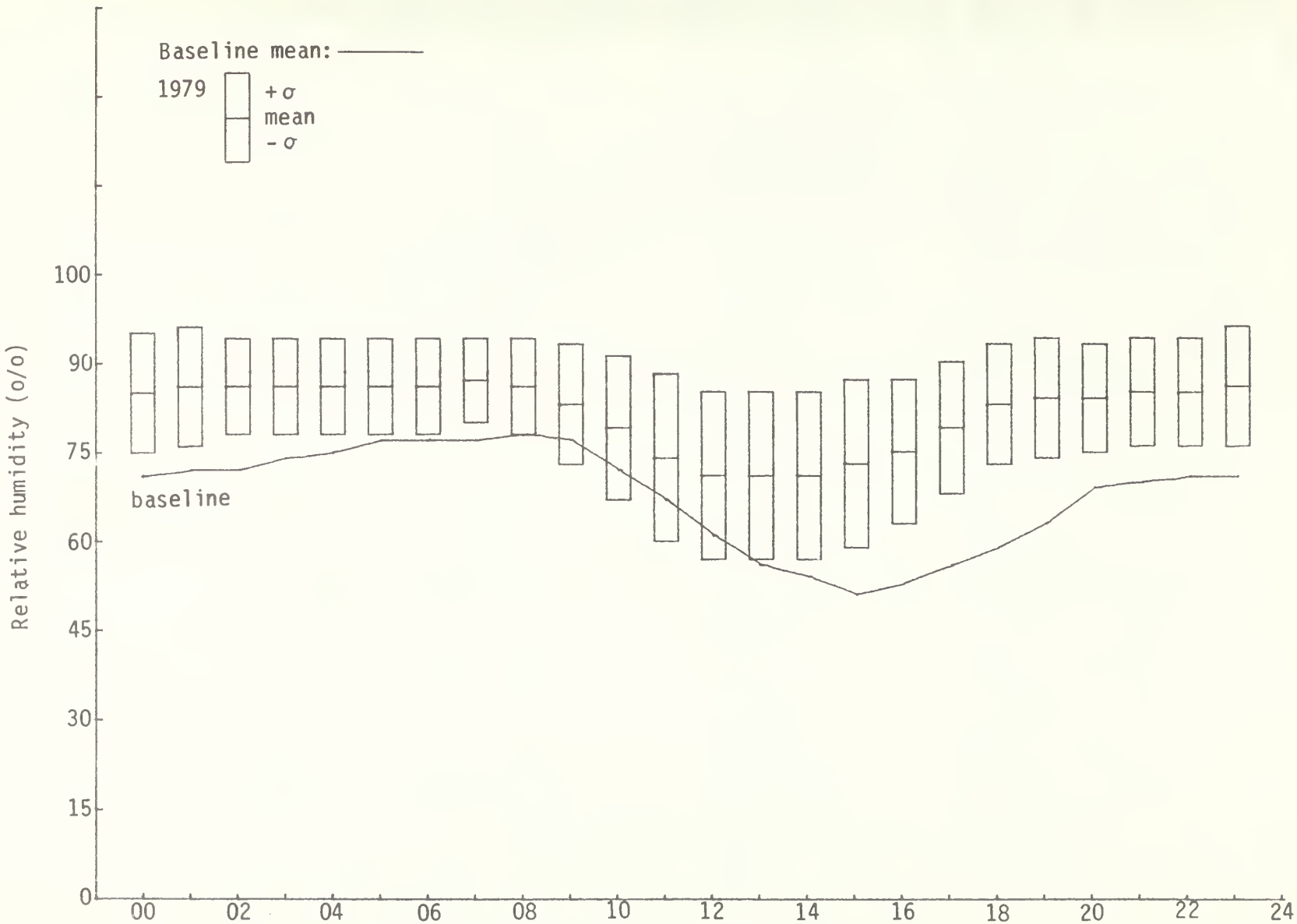


FIGURE 4.2-19. Diurnal variation of mean relative humidity readings and their standard deviations compared to the Baseline means at Site A6 during January 1979.

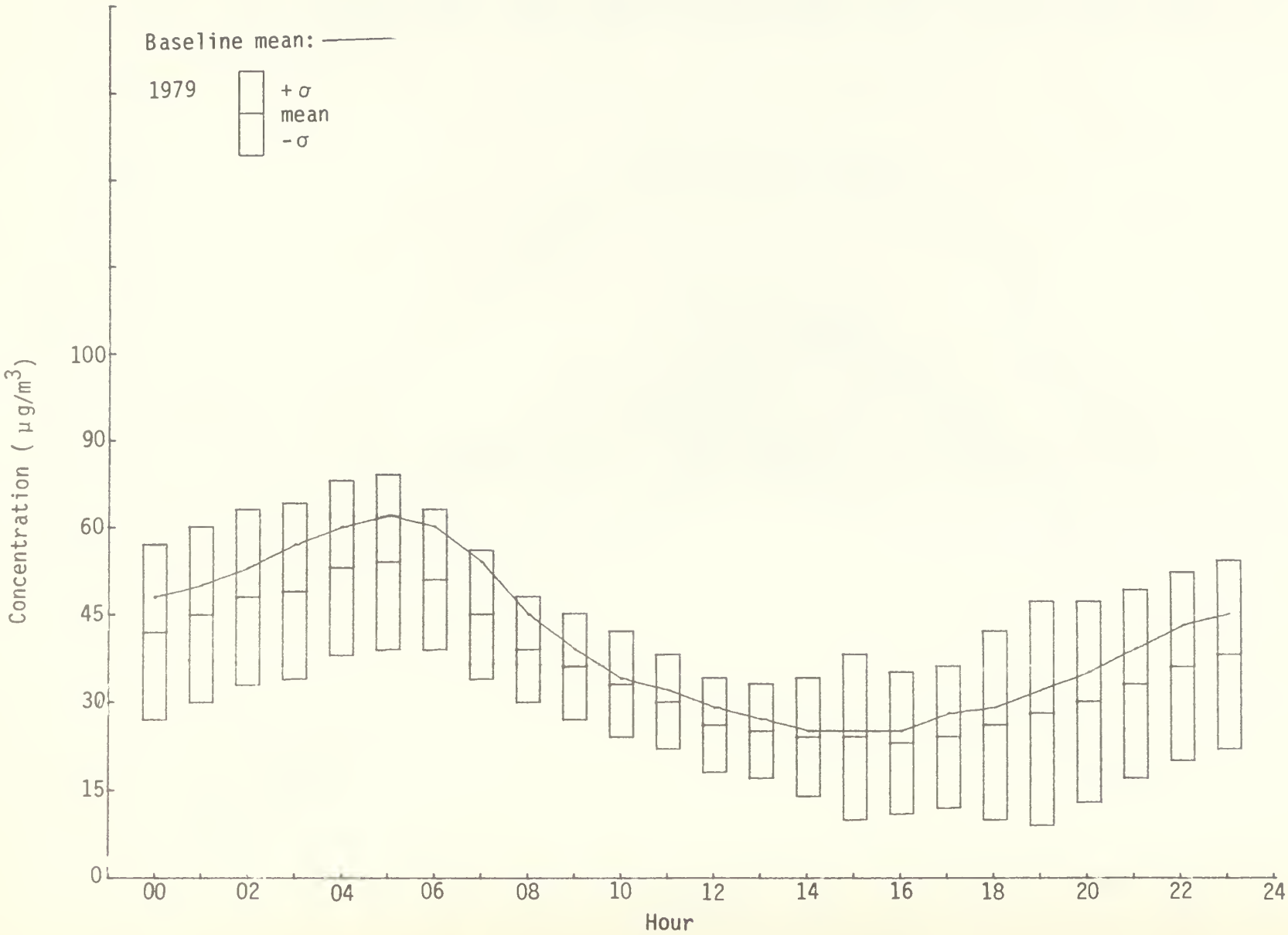


FIGURE 4.2-20. Diurnal variation of mean relative humidity readings and their standard deviations compared to the Baseline means at Site A6 during July 1979.

Barometric Pressure

Figure 4.2-21 gives the mean monthly barometric pressure plus standard deviations, as well as the maximum and minimum monthly barometric pressure at Site A-6 for 1979. The highest value observed was 643 mm of Hg during January 1979, and the lowest value was 606 mm of Hg during April 1979. The winter storms during October through March cause the lowest readings and the basin highs bring the highest readings. During the summer the air mass systems are much weaker and, consequently, not much change in the pressure is evident.

Net Solar Radiation

Several major problems occurred with the instruments during 1979. There is insufficient data for a meaningful statistical comparison with the Baseline data.

Diffusivity

When a gaseous pollutant in the form of a plume or puff is released into the atmosphere it is transported by the prevailing wind. As it travels downwind, its concentration decreases as its volume increases. Its growth in the vertical is governed mainly by the atmospheric stability, while its growth in the horizontal depends not only upon stability but also mechanical turbulence. Mechanical turbulence is defined as irregular airflow induced by surface roughness. A surrogate of mechanical turbulence is the fluctation of wind direction or sigma theta.

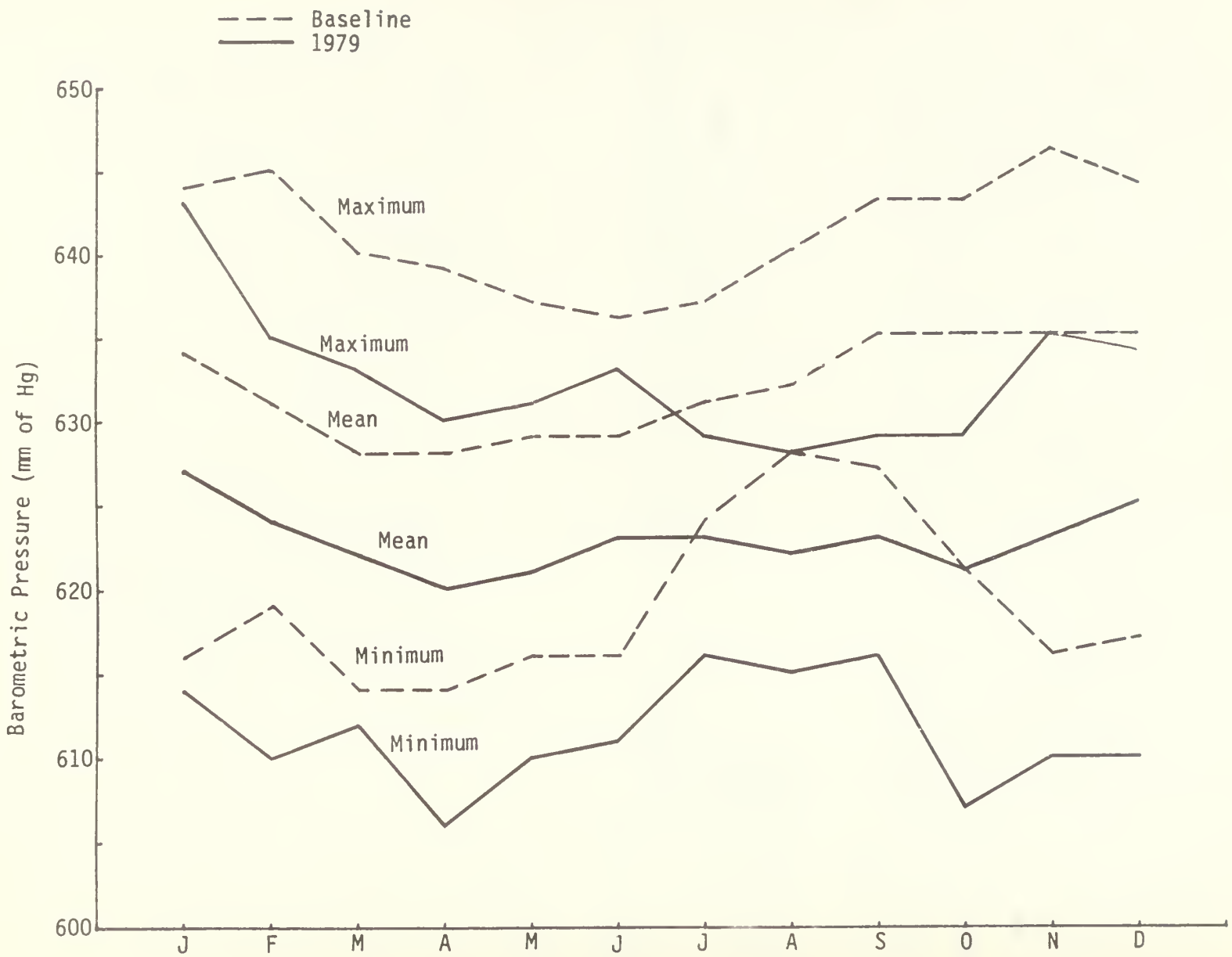


FIGURE 4.2-21. Monthly mean, maximum, and minimum of the barometric pressure at Site A6 during 1979 compared to Baseline.

Using σ_θ data at Site A-6, the frequency distribution of different "stability" (or better "diffusion") classes is computed and presented in Table 4.2-18. The classification scheme used follows that in the Atomic Energy Safety Guide 23 (AEC, 1972) and appears in Table 4.2-19.

When the entire year is considered, stability Classes D and E are most prevalent on the tracts. Data collected at Site A-6 shows that variability in stability classes with atmospheric conditions is greatest during winter and the overall pattern is still tending toward a stable atmosphere. Comparison with the baseline value shows no significant changes.

A complete dispersion picture must also include the effect of plume rise. The meteorological parameters that greatly influence the height of a plume are atmospheric stability and wind speed. Vertical atmospheric stability can be best defined by ΔT data. In equations derived by Briggs (1974) for calculating plume height, only three atmospheric stability classes are needed. The classification scheme is listed in Table 4.2-20.

Figures 4.2-22 and 4.2-23 present the diurnal variation of ΔT collected at Site A-6 for two months, January (winter) and July (summer) 1979. Note that very stable or slightly stable atmospheric conditions prevailed in early morning and evening during July. In the afternoon, neutral or unstable conditions were a general rule. Because of the almost continuous cloudiness throughout the month of January, the development of strong nocturnal stability was prohibited. Thus, there was only a small diurnal variation in the mean ΔT and the stability was almost always slightly stable or neutral throughout the day.

TABLE 4.2-18. Relative frequency distribution (%) of stability classes at Site A6 for the Baseline Period and 1979, using σ_θ. Table 4.2-6 defines the classes A through F.

Period	Season	Stability Classes						Total Number of Observations
		A	B	C	D	E	F	
Baseline	Winter	.7	.8	6.2	27.2	46.8	18.3	2,204
	Spring	.3	.5	5.4	29.3	58.4	6.1	2,208
	Summer	.0	.0	3.1	36.5	54.6	5.8	2,117
	Fall	.0	.4	6.2	27.2	46.4	19.8	2,182
1979	Winter	.6	1.9	7.1	29.1	46.2	15.1	2,110
	Spring	.8	4.2	10.4	27.7	47.6	9.3	2,206
	Summer	2.6	7.9	14.6	28.6	36.9	9.4	2,208
	Fall	2.2	6.4	11.9	23.2	38.0	18.3	2,184

TABLE 4.2-19. Classification of atmospheric stability.

Stability Classification	Pasquill Categories	σ_θ* (degrees)
Extremely unstable	A	25.0
Moderately unstable	B	20.0
Slightly unstable	C	15.0
Neutral	D	10.0
Slightly stable	E	5.0
Moderately or very stable	F	2.5

Source: Atomic Energy Safety Guide 23 (AEC, 1972)

*Standard deviation of horizontal wind direction fluctuation over a period of 15 minutes to one hour. The values shown are averages for each stability classification.

TABLE 4.2-20. ΔT stability scheme.

Stability	ΔT ($^{o}C/100m$)
1. Unstable and Neutral	-0.5
2. Slightly Stable	-0.5 to 1.5
3. Very Stable	1.5

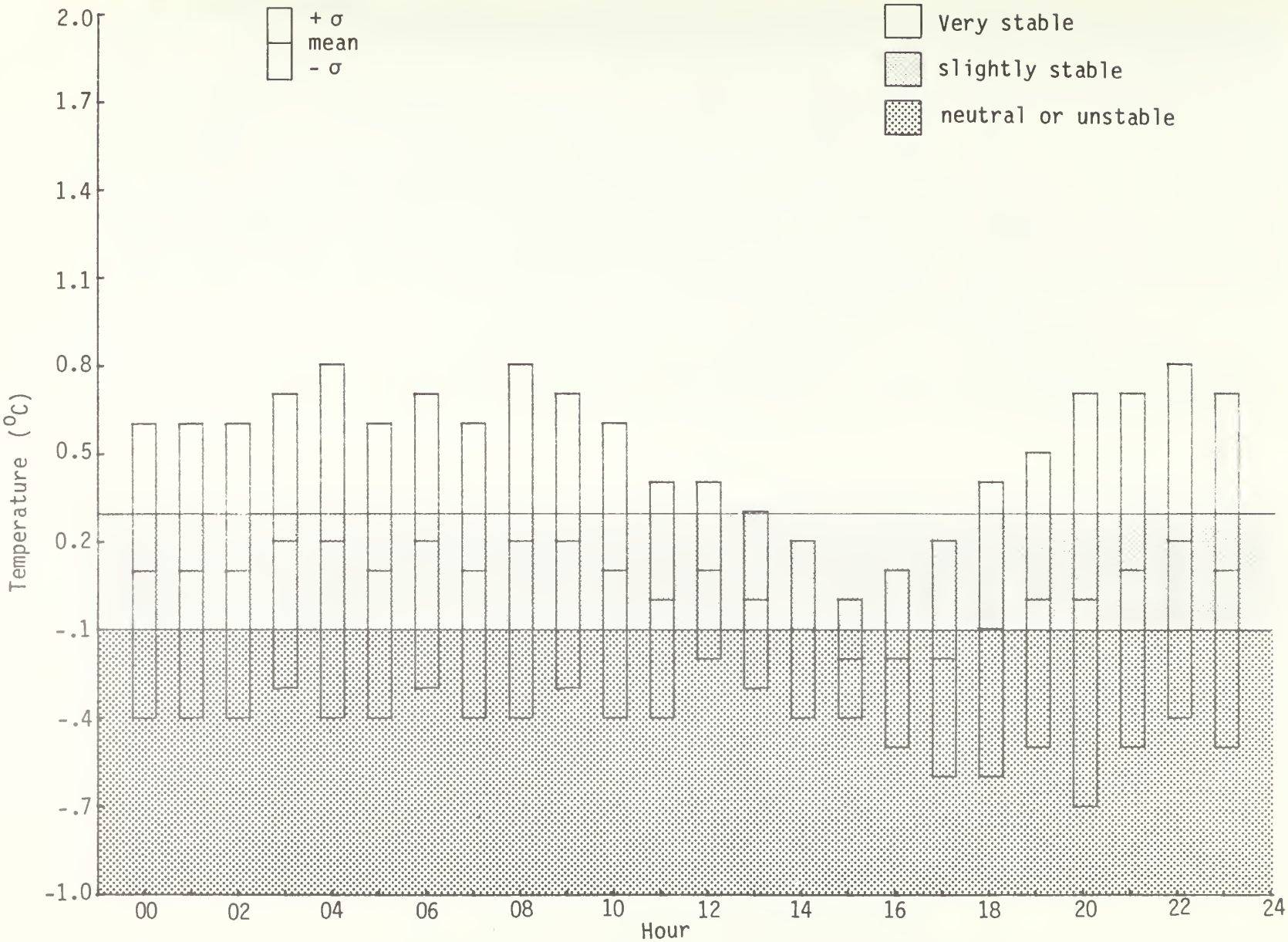


FIGURE 4.2-22. Diurnal variations of the mean ΔT and their standard deviations at Site A6 during January 1979.

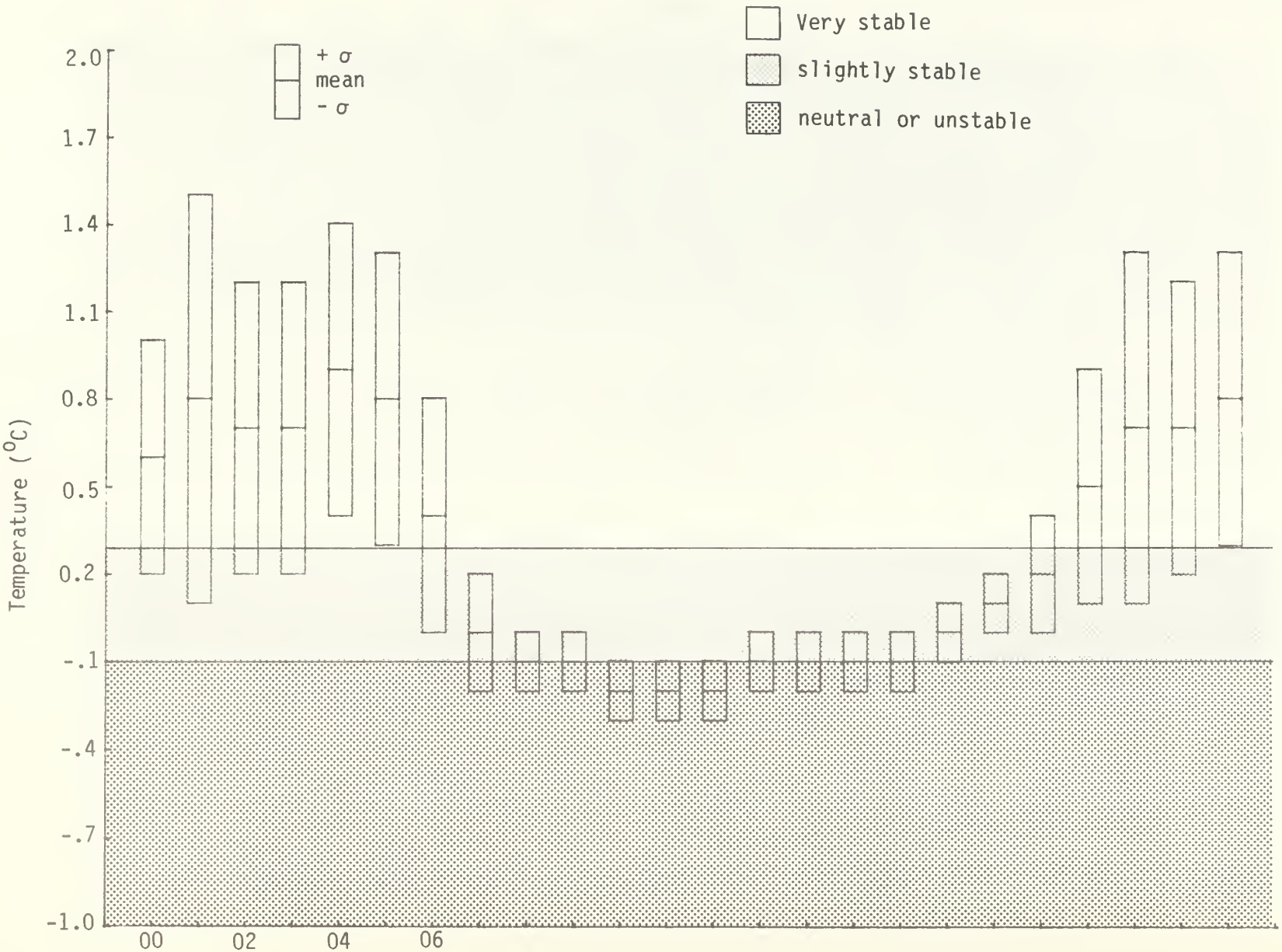


FIGURE 4.2-23. Diurnal variations of the mean ΔT and their standard deviations at Site A6 during July 1979.

The frequency distribution of stabilities based on ΔT appears in Table 4.2-21. This shows that very stable conditions occurred less frequently during spring, whereas unstable or neutral activities occurred more often during spring. Total accuracy of the ΔT system used at Site A-6 during the Interim year differed from that used during the Baseline period. The system for the Interim year measures ΔT to within $\pm 0.1\ ^{o}C/20$ meters over the measurement interval. Accuracy was below this level in the Baseline period; hence, no comparison of the ΔT data is attempted for these two periods.

Joint Frequency Distributions

Joint frequency distributions for wind speed, wind direction, diffusivity, and stability were constructed for Site A-6 for 1979. The joint frequency distributions were categorized into vertical atmospheric stability classes, as defined by ΔT, and turbulence intensity (or diffusion) classes as defined by σ_θ. The classification schemes are shown in Tables 4.2-19 and 4.2-20, respectively. This type of information, with some modifications, is useful as input into many climatological dispersion models, such as the EPA's CDM model, to compute annual average of a particular pollutant.

Examining the entire set of joint frequency distributions, one finds the combination of very stable atmosphere with low wind speed (<3.5 m/s) occurred 24.2% of the time during the entire year, with such occurrences most frequent (29.1%) during the summer. This combination of meteorological conditions is very conducive to high ground-level pollutant concentrations. Table 4.2-22 shows the relative frequencies of such occurrences by seasons and for the entire year.

TABLE 4.2-21. Relative frequency distribution (%) of ΔT at Site A6 for 1979.

Season	Stablility (ΔT in $^{o}C/100m$)			
	Unstable or Neutral (<-0.5)	Slightly Stable (-0.5 to 1.5)	Very Stable (>1.5)	Total Number of Observations
Winter	46	13	41	2,110
Spring	54	17	29	2,206
Summer	40	17	43	2,208
Fall	45	13	42	2,184
All Year	46	15	39	8,708

TABLE 4.2-22. Relative frequency (%) of low wind speed (<3.5 m/s) combined with very stable atmosphere within each season and for 1979 at Site A6.

Season	(%)	Frequency Total Observations
Winter	25.28	1,971
Spring	18.94	1,311
Summer	29.14	1,124
Fall	23.26	1,365
All Year	24.16	5,771

4.3 BIOLOGICAL RESOURCES

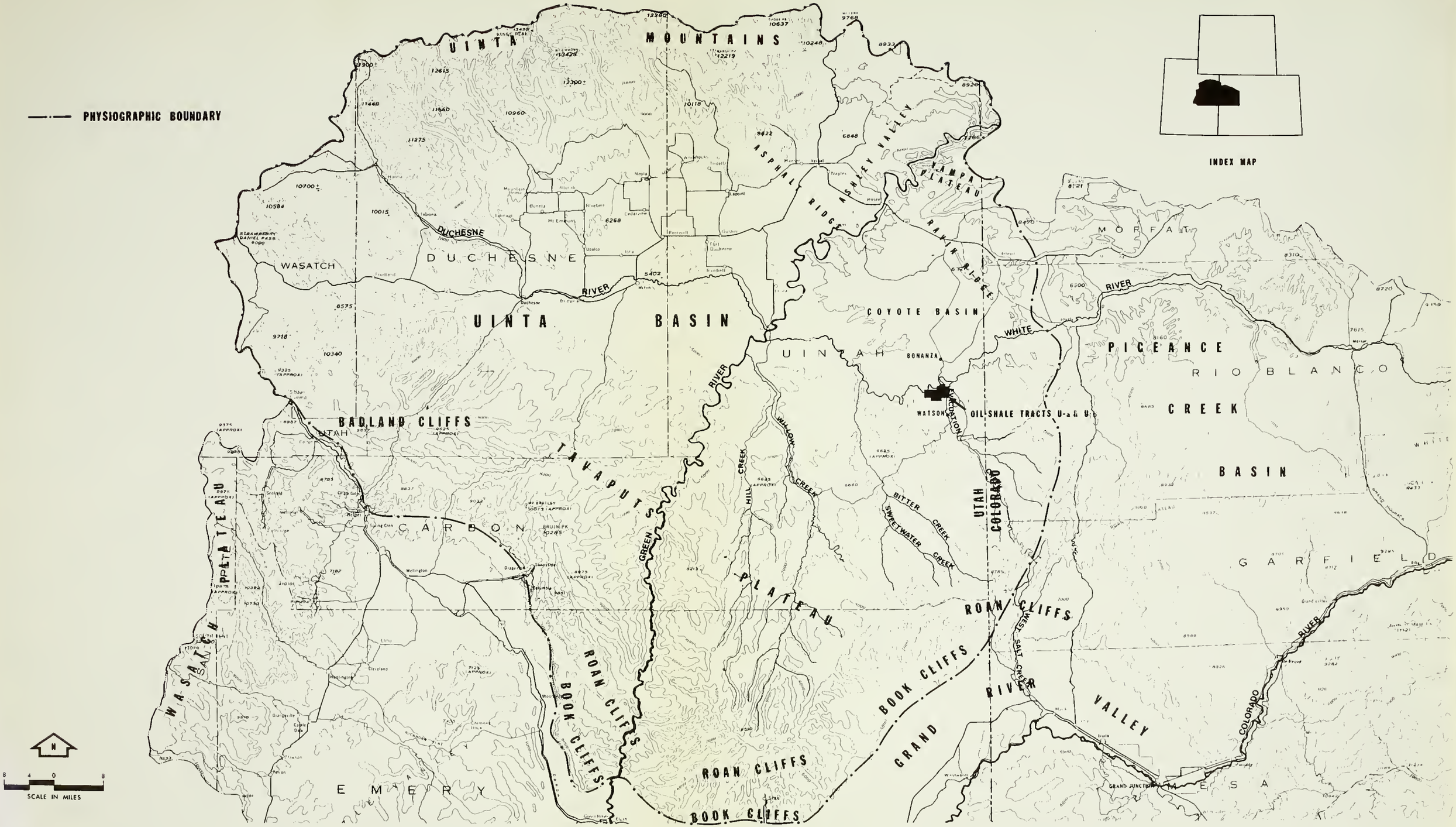
Biological resources monitoring for the two-year Environmental Baseline Monitoring Program was completed in January, 1977. At that time an Interim Monitoring Program was implemented. This section discusses predominantly the work conducted during 1979 as a part of this program.

Tracts Ua and Ub are within the eastern portion of the Uinta Basin, a broad, northwest-facing asymmetric basin on the northeastern edge of the Colorado Plateau (Figure 4.3-1). The Uintah Basin overlies alluvial sediments of a prehistoric depositional lake basin. Major land features bordering the basin are the Uinta Mountains on the north, the Wasatch Range on the west, the Roan and Book cliffs on the south, and the highlands associated with the subsurface Douglas Creek Arch along the eastern edge.

The Green River, flowing generally southwestward, is the major drainage within the basin. A portion of its water comes from the westward-flowing White River, its headwaters in the White River Plateau of Colorado and the eastward-flowing Duchesne River, its headwaters in the Uinta Mountains.

Tracts Ua and Ub are bounded by the White River to the north, Hell's Hole Canyon to the east, upland areas of elevations between 1829 and 1890 m (6000-6200 ft) to the south, and Asphalt Wash to the west. The region near the tracts, including the area extending southward to the Roan Cliffs and westward to the Green River, is a gently north-sloping, highly dissected plateau characterized by steep-walled canyons with ephemeral streams or dry washes.

Within the tracts the landscape is composed of a series of north-south-trending valleys separated by narrow, elongated mesas. Thirty-three



PHYSIOGRAPHIC MAP OF THE UINTA BASIN REGION

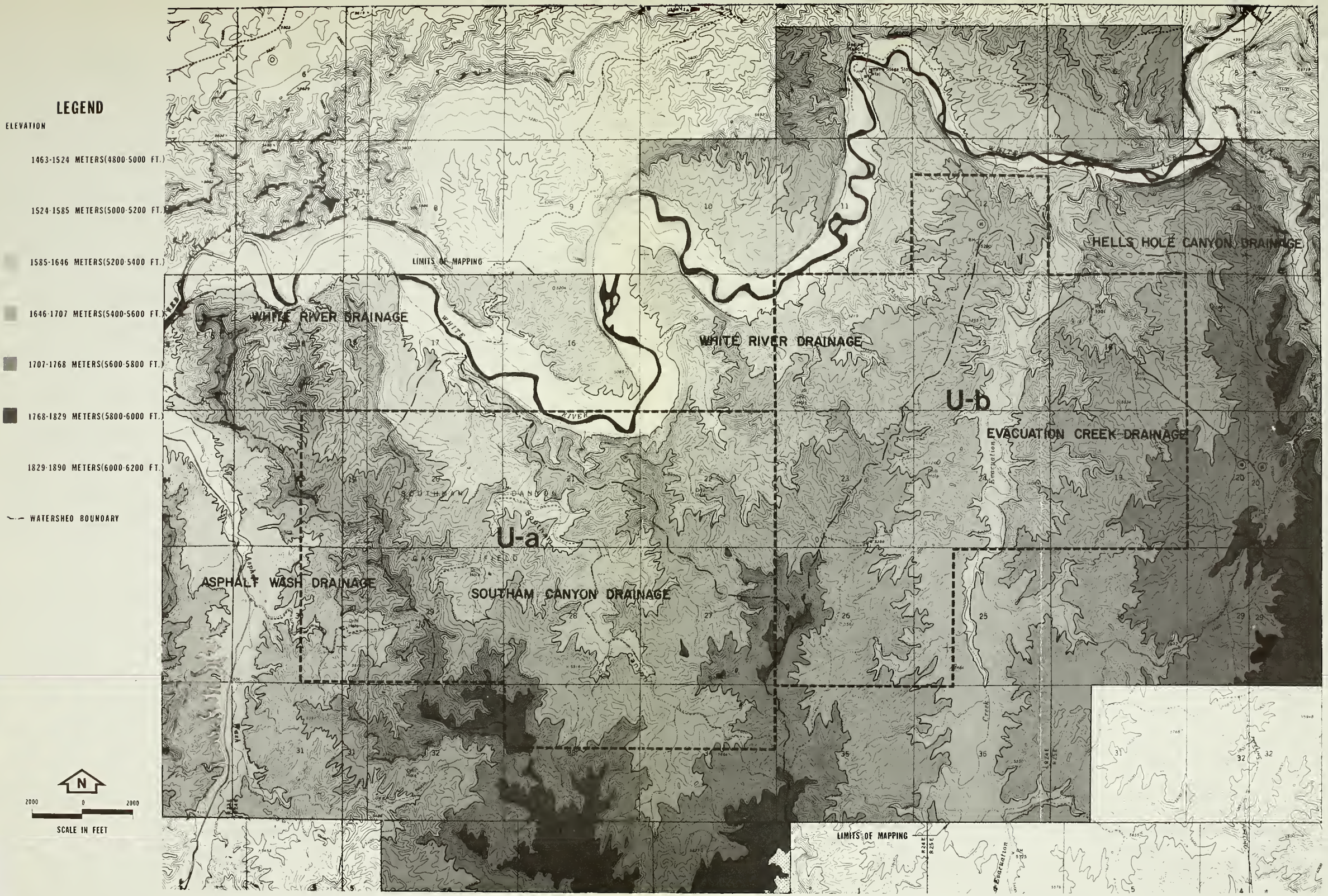
FIGURE 4.3-1

percent of these tracts drains into Evacuation Creek, 31 percent is in the Southam Canyon drainage, 30 percent drains directly into the White River, and six percent is in the Asphalt Wash drainage. Elevations range from 1500 to 1890 m (4920-6200 ft.) (Figure 4.3-2).

The White River is the only perennial stream running through the tracts, although Evacuation Creek contains surface flow for several months of the year, mainly from brackish and, in some places, poisonous ground water discharge from the Bird's Nest aquifer. Southam Canyon, Asphalt Wash, and tributaries of Evacuation Creek and the White River are all ephemeral.

The soils along the flood plain of the White River and along smaller drainageways throughout the area have formed in alluvium. The alluvium along the White River has come from a wide range of transported materials, whereas in the small drainages the materials are largely deep, sandy loams and channery, sandy loams derived locally from the Uinta and Green River formations. The parent material for the upland soils is also the Uinta and Green River formations, over which the soils are shallow or very shallow.

The tracts are in the Colorado Plateau physiographic province, distinguished by the nearly level bedrock and the numerous canyons and generally high elevation. Most of the area is between 1520 and 1850 m (5000 and 6000 ft.) above sea level. The topography of the area is sloping to steep slopes ranging from about 5% to over 60%. The western part of the tracts is characterized by numerous nearly vertical sandstone cliffs. The eastern part of the tracts, east of Evacuation Creek, has more rolling topography and fewer sandstone cliffs.



DRAINAGE BASIN SHADED RELIEF MAP

FIGURE 4.3-2
Page 4.3-4

Shrubs, forbs, and grasses are the dominant vegetation over much of the area. Juniper trees are common at higher elevations above 1650 m (5400 ft.) west of Evacuation Creek, with scattered pinyon pine at the highest elevations. There is an open stand of large cottonwood trees along the White River valley, and young willows and tamarisk grow in the most recent deposits. Big sagebrush is the dominant vegetation along numerous drainageways throughout the area. Shadscale, black sage, cheatgrass, Indian ricegrass, squirrel tail, and some forbs are common on shallow upland soils. Greasewood and shadscale are common in alkali-affected areas.

Plant-available moisture is the most important factor in the distribution of vegetation types in the arid west, and soil characteristics are one of the important factors that determine plant-available moisture. As a result, the distribution of vegetation types often corresponds to the distribution of soil types. On the tracts, where vegetation-pattern and soil-type distribution coincide, it is usually a function of soil moisture.

Greasewood occurs exclusively on the D soils at the site. D soils are the deep, sandy loam soils forming in alluvium. They occur in the relatively narrow drainages below steeply sloping soils and rock outcrops. The soil has a relatively high water-holding capacity. The correlation between areas of D soil and areas of greasewood vegetation is the closest of any of the soil-vegetation relationships at the site.

Riparian vegetation, as the name implies, is found only in areas adjacent to water and on moist soils. The soils of the site that are moist enough to sustain this type of vegetation are W soils and D soils.

The W soils are deep, imperfectly drained, and form in silty alluvium adjacent to the flood plain of the White River. All of the W soils mapped at the site support riparian vegetation. Riparian vegetation also occurs along Evacuation Creek where D soils are moist enough.

The upland soils at the site are similar, but support a variety of vegetation types. The juniper type is found at the high elevations on the thin, sandy soils (As, Bs, and F). These are shallow and very shallow sands, sandy loams, or loams. The eastern limits of juniper roughly coincide with the limits of these soils along the west side of Evacuation Creek. However, the same soils extend beyond the limits of the juniper type because juniper is limited by altitudinal requirements. The thin sandy soils that are below the juniper-vegetation limits to the north and to the west are dominated by big sagebrush.

The A and B soils have formed on the Green River Formation. Very shallow loam soils, they are less sandy than the upland soils found on the Uinta Formation. The vegetation on these soils is exclusively the shadscale-black sagebrush type. The shadscale-black sagebrush type is not limited to soils A and B, but also dominates the sandy soils (As, Bs, and F) that occur north of the White River.

Plant communities on the tracts are sagebrush-greasewood, juniper, shadscale, and riparian (Figure 4.3-3). The dominant shrubs in the sagebrush-greasewood community are big sagebrush (Artemisia tridentata), greasewood (Sarcobatus vermiculatus), and shadscale (Atriplex confertifolia). Other major shrubs associated with the community include horsebrush (Tetradymia spp.), hop sage (Grayia spinosa), and black sage (Artemisia nova). The

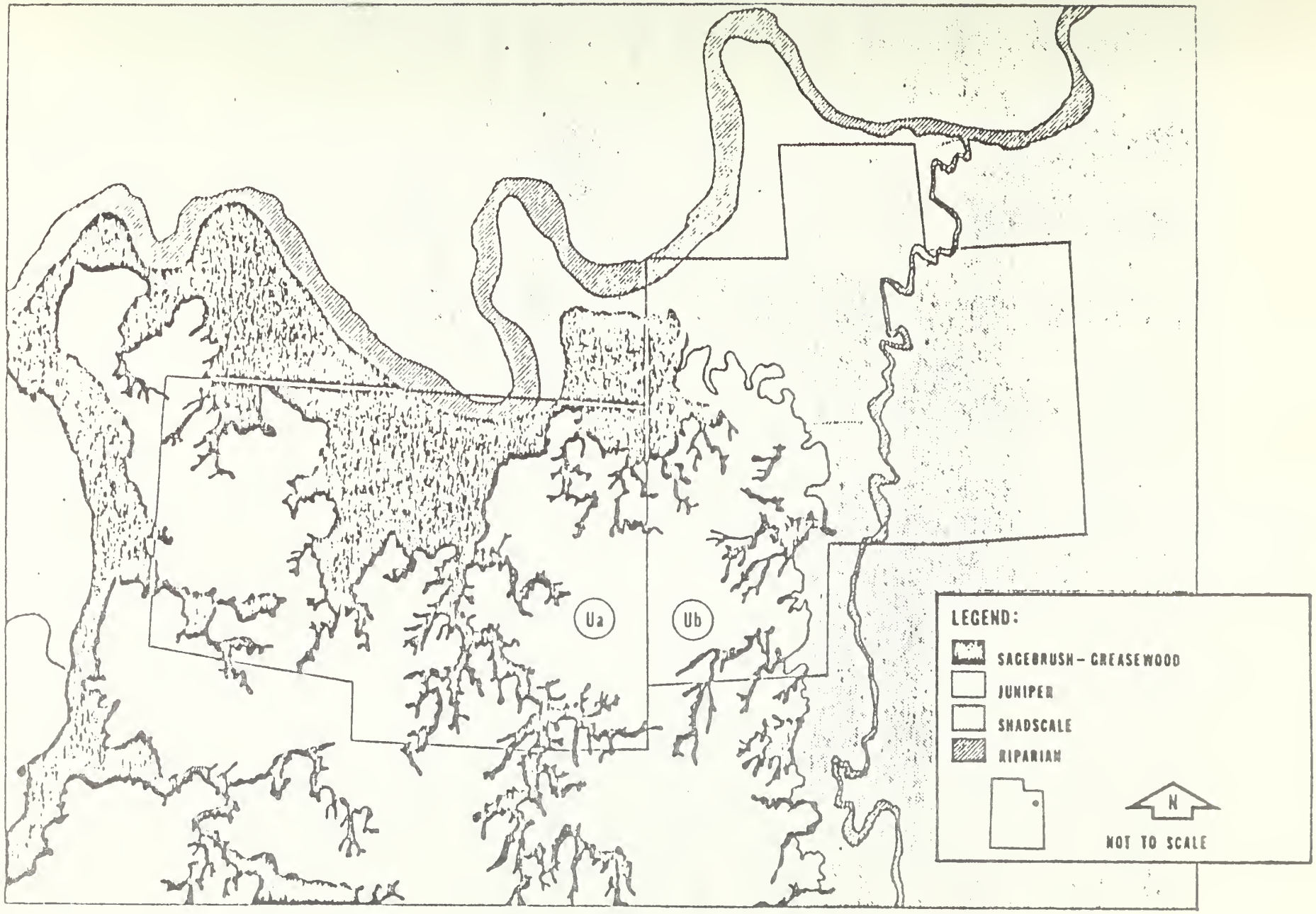


Figure 4.3-3. Vegetation types on the Utah Oil Shale Tracts (After map by VTN, Inc., 1977).

dominant herbaceous species persisting into fall include Russian thistle (Salsola kali), snake weed (Gutierrezia sarothrae), and rabbit brush (Chrysothamnus spp.). Both Russian thistle and rabbitbrush are indicative of heavily grazed if not overgrazed vegetation. Chrysopsis (Chrysopsis spp.), fleabane (Erigeron engelmannii), prickly pear (Opuntia spp.), and winterfat (Eurotia lanata) are other major species.

Cheatgrass (Bromus tectorum) is the dominant grass in the spring. Indian ricegrass (Oryzopsis hymenoides), needle-and-thread grass (Stipa comata), and Galleta grass (Hilaria jamesii) are subdominant grasses which persist into fall and represent the dominant fall grasses. Cheatgrass and needle-and-thread grass provide good forage while young, but poor forage when mature. The borage family (Boraginaceae) and mustard family (Cruciferae) provide the dominant spring herbs. Mentzelia (Mentzelia albicaulis), squirrel tail grass (Sitanion hystrix), Cleome (Cleome lutea), and red sage (Kochia americana) are other major species that appear in the spring.

The juniper community is dominated by Utah juniper (Juniperus osteosperma). Only four pinon pines (Pinus edulus) were encountered during the field sampling. Black sage and to a lesser extent shadscale and big sage are the major shrubs. Snakeweed, spurge (Euphorbia spp.), wild buckwheat (Eriogonum spp.), rabbitbrush, and fleabane are the major herbaceous species persisting into fall.

Galleta grass and Indian ricegrass are the dominant grasses in the spring and persist into fall. Spring herbs are dominated by the borage family, wild buckwheat, red sage, and sweet vetch (Hedysarum boreale).

Other spring species include pepper grass (Lepidium montanum) and other species in the mustard family, needle-and-thread grass, Kentucky bluegrass (Poa pratensis), cheatgrass, phlox (Phlox hoodii), and lambs quarter (Chenopodium album).

The dominant shrubs of the shadscale community are shadscale and big sage. The other major shrubs include black sage, greasewood, and to a lesser extent hop sage and horsebrush (Tetradymia spinosa). Herbaceous species persisting into fall include rabbitbrush, snakeweed, halogeton (Halogeton glomeratus), milk vetch (Astragalus spp.), and Russian thistle. As in the sagebrush-greasewood community, the rabbitbrush, halogeton, and Russian thistle are indicative of heavy grazing pressure. Indian rice-grass is the dominant fall grass, with needle-and-thread grass and Galleta grass represented to a lesser extent.

Cheatgrass dominates the spring growth, with blue mustard (Chorispora tenella) and other species in the mustard family the dominant herbs. Other spring species include wild buckwheat, Indian ricegrass, squirrel tail grass, stickseed (Lappula redowskii), and other species of the borage family; and globe mallo (Sphaeralcea coccinea), Galleta grass, Mentzelia, and onion (Alluim spp.).

Cottonwood (Populus fremontii) dominates the riparian community along the White River, with saltcedar (Tamarix pentandra) the dominant under-story shrub. In the riparian area along Evacuation Creek, saltcedar and greasewood are the dominant shrubs. Horsetail (Equisetum arvense), rabbitbrush (Chrysothamnus viscidiflorus and C. nauseosus) and wire rush (Juncus balticus) are also dominant understory plants. Other major shrubs

include greasewood, willow (Salix exigua), saltbrush (Atriplex patula), and big sage. Russian thistle, yellow sweet clover, and snakeweed are the major herbaceous species persisting into the fall. Saltgrass (Distichlis stricta) is the dominant grass in the fall, with western wheatgrass (Agropyron smithii) and to a lesser extent muhly (Muhlenbergia asperifolia) and Kentucky bluegrass the other major grasses persisting into the fall. Spring growth is dominated by cheatgrass. Pepper grass (Lepidium perfoliatum) and other species of the mustard family, yellow sweet clover, saltgrass, and western wheatgrass are the major spring plants. Other herbs and grasses occurring in the riparian community include Kochia (Kochia spp.), stickseed and other species of the borage family, Kentucky bluegrass, blue mustard, smother weed (Bassia hyssopifolia), six weeks fescue (Festuca octoflora), sand bur (Cenchrus pauciflorus), snakeweed, the root parasite bastard toad-flex (Comandra pallida), ragweed (Ambrosia psilostachya), poverty weed (Iva axillaris), alkali sacaton (Sporobolus airoides), sagebrush (Artemisia ludoviciana), and reed (Phragmites communis).

The major factors determining the distribution, composition, and structure of the plant communities are primarily soils and available water. The cottonwood-dominated riparian community is restricted to the area along the White River where available water is abundant. The juniper community occurs in the higher elevations where soils are very thin and poorly formed.

The sagebrush-greasewood and shadscale communities occur in the areas of relatively low relief, with the sagebrush-greasewood community occurring in the swale areas with relatively deeper soils. The major plant species

occurring in both communities are almost identical; however, the dominance of different species distinguishes one community from the other. The shadscale community is dominated by shadscale and big sage, which have shallow root systems relative to greasewood, a co-dominant with shadscale and big sage in the sagebrush-greasewood community.

Of the major shrub species, shadscale and big sage are the dominant species in the sagebrush-greasewood and shadscale communities and are the major shrubs in the juniper community. Black sage is a major shrub in all three communities relative to big sage and shadscale, but it is the dominant understory shrub in the juniper community.

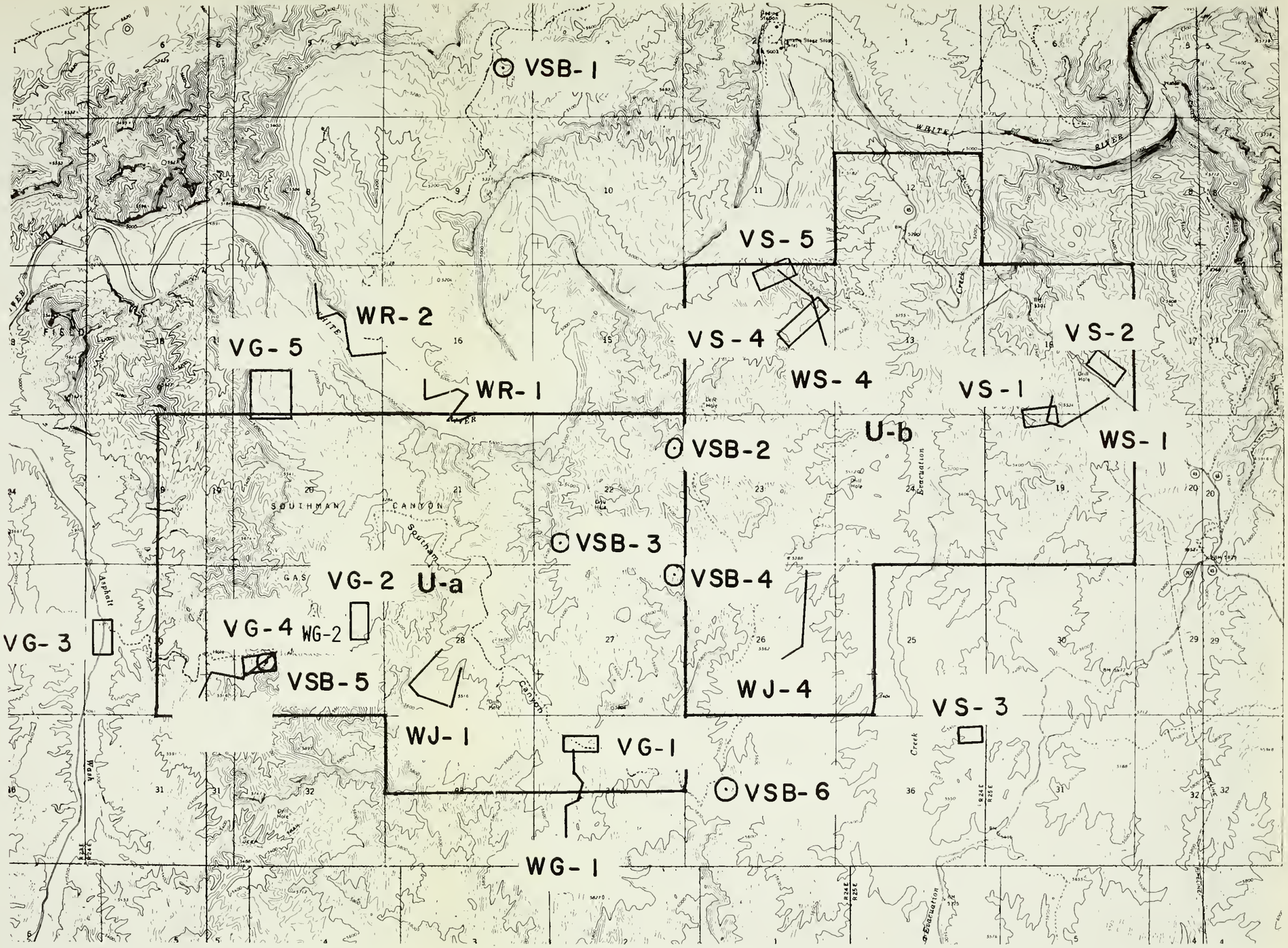
Indian ricegrass is a dominant fall grass in all three communities. Galleta grass is a fall co-dominant in the juniper and shadscale communities, and needle-and-thread grass is a fall co-dominant in the shadscale and sagebrush-greasewood communities. In spring the dominant grasses in the juniper community are Indian ricegrass and Galleta grass, while cheatgrass is the overshelmingly dominant grass in the sagebrush-greasewood, shadscale, and riparian communities.

Rabbitbrush is a major herbaceous species in all four communities, and snakeweed is a common major herbaceous species in all but the riparian community. Russian thistle is a major plant in the shadscale, sagebrush-greasewood and riparian communities, but is rare in the juniper community.

Figure 4.3-4 shows the locations of the monitoring sites used for vegetation and animal monitoring activities.

FIGURE 4.3-4

VEGETATION/VERTEBRATES MONITORING SITES



LEGEND

□ = VEGETATION - GREASEWOOD
JUNIPER
SHADSCALE

⌃ = WILDLIFE

⊙ = VEGETATION - SAGEBRUSH

4.3.1 Vegetation

The following material discusses the vegetation monitoring work done as a part of the Interim Monitoring Program during 1979. Research during the year consisted mainly of monitoring on-going field studies to determine the degree of stability achieved in establishment. Dr. Cyrus McKell, Utah State University, performed this work under contract with WRSP.

4.3.1.1 Objectives. The major objectives of the vegetation monitoring program are to maintain continuity of data collection on key parameters, determine trends, develop supportive vegetation data for interpretation of animal monitoring results, and to explore "control" versus "treatment" systems of monitoring oil shale development impacts.

The 1979 vegetation work plan also included a series of additional studies to identify and evaluate various parameters which may influence our revegetation efforts.

4.3.1.2 Methods. The approach used during the 1979 Interim program followed procedures established during previous years, namely measuring plant productivity and stem growth and visually inspecting the condition of the vegetation.

Two periods of monitoring were emphasized: June, when annual plant species are at their peak of production; and October, when the majority of shrubs have achieved their ultimate growth in stem leader and seed production for the year.

In June, 1979, five productivity study areas were visited in each of the four vegetation types monitored during the Baseline program. In each study area, above-ground biomass was harvested from 10 quadrants, each

with an area of 0.25 meters, in five separate locations. Plants were measured for height, clipped at ground level, and returned to the laboratory for analysis. Notes on vegetation conditions were recorded relative to plant density and the patchiness of plant production in the more favorable growth sites. Estimates of plant cover were also obtained where the vegetation was measured.

There was no change in methodology for the stem growth measurements in 1979 from those used in previous years. The current growth of 20 stems from 20 separate plants in each of six sampling sites was measured. Each measurement was from the bud-scale scar of the previous year to the tip of the new growth.

To determine the effect of annual plant competition on survival and growth of several transplanted species, both container growth and bare-root stock were planted in two locations during the spring of 1977.

Two uniform experiments to evaluate the effect of plant age and vegetative pruning on the survival of fourwing saltbush grown as bare-root stock were field planted in the spring of 1978 at two locations. Plants of one, two, and three year old field grown bare-root stock were compared for survival. The three levels of pruning for comparison were unpruned (control), lightly pruned (leaving half of the top biomass), and heavily pruned (leaving the stumps with only 1 to 3 inches of stems above the ground).

Several studies were continued from the Final Revegetation Study including plant survival and growth comparing season and planting methods of shrubs and grasses, plantings in processed shale, and soil over shale-filled plots, and water harvesting studies.

Another study was established at a field research site near the tracts in June, 1978. Five plants (Atriplex canescens) were innoculated during greenhouse growth with an infusion of mycorrhizae obtained from fourwing saltbush plants and soil at the test site. Five additional plants were not involved and provided control. After sufficient greenhouse development the plants were removed to the test site and transplanted.

Also, during 1979 a survey of endangered plant species was conducted on the tracts.

4.3.1.3 Data Summary. Compared with previous years since 1975, the growing season of 1979 was about average. Temperature and precipitation were not extreme and caused no significant plant responses. Average precipitation at the RS-13 site (on-tract) was 9.83 inches (see Table 4.3-1). Precipitation at the Section 6 test site was 10.3 inches during 1979. Experiments with outplanting container-grown shrubs and grasses in fall vs. spring have reached a good equilibrium with very few plants lost in 1979. This stability is very noteworthy.

4.3.1.3.1 Biomass Production and Plant Cover. The productivity results for each vegetation type have been summarized in Table 4.3-2 and are discussed below.

A. Shadscale Sagebrush Vegetation Type

Annual plants of this vegetation type were relatively dense in favorable microsites, but in some interspace areas very few plants were growing. Average height of the dominant species (Bromus tectorum) was 15 cm (6 inches). Average cover per quarter meter plot was 116 cm^2 of 46%.

Table 4.3-1. A comparison of precipitation for 1976 through 1979 for sites in the Utah Oil Shale Tracts accumulated according to plant growth year (October through September)

	Precipitation (inches)			
Month/Year	1976*	1977**	1978*	1979*
October	1.47	0.10	0.96	0.53
November	0.37	0.00	1.58	1.37
December	0.66	trace	0.30	1.00
January	0.22	0.30	1.51	1.05
February	0.39	0.65	0.35	0.00
March	1.18	0.77	1.00	1.50
April	0.75	1.30	1.45	0.97
May	1.44	0.37	0.15	1.21
June	1.20	0.04	0.00	trace
July	0.47	1.18	0.00	0.51
August	0.66	1.22	0.47	1.60
September	0.98	0.68	0.34	0.09
Total	9.79	6.61	8.11	9.83

* Precipitation at Site RS-13
** Revegetation Site

Table 4.3-2. Biomass production of annual understory vegetation in each of the four primary vegetation types during 1979 and compared with previous year productivity.

Sample 1/ Location	BIOMASS PRODUCTION (gm/m^2) VEGETATION TYPE			
	Shadscale	Greasewood	Juniper	Riparian
1	10.3	21.7	6.0	30.9
2	16.4	24.9	13.8	100.1
3	33.2	4.6	2.7	241.6
4	11.6	9.5	5.6	14.6
5	10.8	24.1	3.6	25.0
1979 Average	16.5	16.9	6.3	82.5
1978 Average	5.4	35.1	1.6	80.0
1977 Average	2/	2/	2/	20.6
1976 Average	3.8	20.9	0.25	533.3
1975 Average	224.3	51.1	3.8	30.6

1/ Each value is a mean of data from 10 plots within areas sampled during Baseline study.

2/ Vegetation not sampled (too meager to harvest).

B. Sagebrush-Greasewood Vegetation Type

Annual plants in this vegetation type were abundant in protected microsites. Stipacomata and Oryzopsis hymenvides showed vigorous growth and excellant seed production. Bud sagebrush was making good growth and recovery from minimum growth during previous years. Signs of animal use were less than previous years when drought forced wildlife to consume the bark of greasewood and the spiney pads of prickly pear cactus. Average cover per quarter meter plot was 25 cm^2 of 10%.

C. Juniper Vegetation Type

As in previous years, the understory vegetation in the juniper type was very limited and restricted to microsites were protection from grazing and insoluation encouraged growth. Understory biomass was less than either the shadscale or the sagebrush-greasewood types. As in previous years, old juniper litter appeared to restrict annual plant growth under the juniper canopy, while open spaces and areas under sagebrush canopy were the sites of greatest abundance. The junipers showed signs of cold temperature damage during the winter of 1978-1979. Average cover was about 25 cm^2 per 250 cm^2 plot.

D. Riparian Vegetation Type

The riparian habitat continued to be the most productive site on the oil shale tracts. The year of 1979 was good for understory production. Plants continued to grow abundantly in the deep fertile bottom land soil of the White River. Average height of the mainly grass understory was 30 cm (1 foot). Average cover estimates were 15 cm^2 for the river bottom plots as compared with 37 cm^2 in the bottom land of Evacuation Creek.

4.3.1.3.2 Sagebrush Stem Growth. Continued monitoring of sagebush stem (or leader) growth provides a biologically integrated measure of site favorability useful in both baseline and post construction evaluations. The following summarize the results of stem growth measurements at the six selected study sites.

Site 1 is in Section 22 just west of the proposed retort location. Abundant growth was noted in all perennial species (Figure 4.3-5). Greasewood produced abundant seeds which has not been observed for the past two years. Summer weeds were plentiful in disturbed areas although normally bare interspace areas were still bare. Sagebrush stems appeared to be longer than in the past and were supporting an abundance of flowers.

Site 2 is also in the vicinity of the proposed retort area but located about one quarter mile to the east (Figure 4.3-6). Sagebrush leader growth was vigorous and long with many flowers evident on the top of the plants. Russian thistle and halogeton plants were abundant and larger than in the past two years. Annual grass occurrence was spotty.

Site 3 is located near the center of Section 29 along the road to Asphalt Wash and is about four miles west and upwind from the proposed retort site. As in other areas, the shrubs on this site were beginning to flower in a greater abundance than seen for the previous two years (Figure 4.3-7). Stipa and indian ricegrass showed above average growth in 1979 and produced numerous seed stems. Very little annual forbs and grasses were noted on this site. Halogeton was quite evident along the roadway to the north of this site.

Figure 4.3-5. Sagebrush sampling site No. 1, west of the proposed retort area. Abundant growth of perennial species was noted.

Figure 4.3-6. Sagebrush sampling site No. 2, east of proposed retort area. *Grayia spinosa* was later than usual in loosing its leaves.

Figure 4.3-7. Site 3, located on road to Asphalt Wash area has an average density of sagebrush plants. Flowering of shrubs was a major difference in this plot in 1979 compared with other years - except 1976.

Site 4 is located in the west center of Section 35 about two miles south of the proposed industrial site (Figure 4.3-8). Seed production on sagebrush, shadscale, and rabbitbrush was prolific. Late summer annuals such as Russian thistle, halogeton, and lambsquarters plus old litter from spring biomass production were still standing, but their occurrence was spotty and limited to protected areas with more favorable soil conditions. Sagebrush flowers were both abundant and long. Grazing during 1979 was not as obvious as in 1978.

Site 5 is located in the southeast quarter of Section 18 in the shadscale vegetation type. The sagebrush plant community is located primarily on a north-facing slope (Figure 4.3-9). Seed production was abundant. Late summer annual plants, halogeton predominating, were still alive and dense in protected micro sites. Litter from spring plant growth was moderately abundant but spotty in distribution. The area was not grazed as closely as in previous years.

Site 6 is located in Section 4 on the north side of the White River off the oil shale lease tracts. Sagebrush and rabbitbrush were in full bloom and were apparently flowering more than the past two years. Very limited annual plant growth was evident, suggesting a relatively dry spring growing period at this location. Greasewood vegetation was also developing an excellent seed set. No grazing was evident on the site during 1979 when compared with the two previous years. (No photograph was taken of this site due to the late hour of the day when the site was visited.)

Sagebrush stem growth during 1979 reflects a moderately favorable year for biomass production. Stem length at each site was relatively uniform (Table 4.3-3) and no single site appeared to have undergone adverse conditions causing the plants to restrict growth. Average stem length

Figure 4.3-8. Site 4 is in the west center of Section 35 about 2 miles south of this proposed retort site. Plants looked to be in better than average vigor.

Figure 4.3-9. Site No.5 located in a shadscale vegetation type on the eastern edge of the prototype oil shale leases.

Table 4.3-3. Average stem length (cm) as measured September, 1979. Data are mean values for 20 stems from individual, 1980 plants and the standard deviations of such values.

Plant No.	Site 1 Stem Length Average	SD	Site 2 Stem Length Average	SD	Site 3 Stem Length Average	SD	Site 4 Stem Length Average	SD	Site 5 Stem Length Average	SD	Site 6 Stem length Average	SD
1	6.99	1.50	8.31	2.78	10.96	2.30	9.12	2.80	7.70	1.02	8.14	2.09
2	7.97	1.17	10.08	2.77	9.95	3.36	11.50	2.69	9.14	1.48	8.11	1.55
3	9.20	1.85	16.70	7.01	7.33	1.49	9.59	1.69	7.23	1.98	7.04	2.04
4	7.16	2.80	10.20	2.74	11.04	1.86	8.99	2.23	8.34	2.15	8.29	2.19
5	6.28	2.03	7.69	2.97	9.91	2.56	7.20	1.74	8.64	1.48	6.97	2.12
6	5.89	1.70	11.46	2.88	7.87	2.43	5.97	1.39	7.06	1.26	9.10	2.53
7	11.33	4.08	8.52	1.68	8.94	1.78	10.65	3.74	10.14	1.98	6.89	1.24
8	9.15	1.78	4.89	1.30	7.94	1.59	7.42	2.32	8.29	2.25	7.03	1.49
9	9.66	3.49	7.24	2.81	11.11	3.51	7.85	1.19	7.76	1.48	6.97	1.67
10	7.66	1.51	7.61	2.41	14.73	4.75	6.64	2.11	8.73	1.89	5.56	1.17
11	9.43	2.49	10.81	3.23	11.33	2.19	6.48	1.62	5.22	1.65	7.64	1.87
12	8.81	1.96	9.98	2.37	8.56	2.06	9.87	2.62	7.14	2.57	11.31	2.58
13	3.50	0.83	15.95	3.59	12.22	2.88	9.27	2.20	6.90	1.81	7.66	1.35
14	5.80	1.45	7.52	1.53	8.96	2.40	8.29	2.38	4.95	1.98	7.39	1.74
15	5.54	1.52	9.20	2.66	8.91	2.27	6.64	1.83	6.71	1.84	6.39	2.13
16	5.49	1.89	10.91	2.01	9.93	2.36	7.00	1.39	5.17	1.00	7.51	1.74
17	8.47	2.23	11.69	2.32	9.32	1.80	6.82	1.95	5.40	1.94	9.28	2.14
18	7.44	2.27	12.42	2.93	11.02	2.81	7.91	2.21	7.84	2.03	6.40	1.53
19	8.00	1.78	9.62	1.63	7.92	2.15	9.52	2.10	5.26	1.31	7.23	2.04
20	9.55	1.87	7.92	1.52	12.2	2.95	6.80	1.51	7.45	1.99	7.39	2.46
Total	151.74		197.71		199.29		163.44		145.05		152.34	
Average	7.49		9.88		9.96		8.17		7.25		7.67	
SD	2.00		2.73		2.47		2.08		1.75		1.88	

varied from 7.25 cm at Site 5 on the east side of the tracts to 9.96 cm for Site 3 on the road to Asphalt Wash. Sites 1 and 2 near the proposed retort location had average lengths of 7.59 and 9.88 cm, respectively.

The 1979 stem length uniformity was high. Based upon standard deviations for each site, all but Site 5 were within the standard deviation range of Site 3 which had plants with the longest stems.

As this study indicates, stem length appears to be a means of assessing site conditions and the general uniformity or lack of uniformity among the various areas on tract where similar plant communities occur. As this study continues, its value increases as an index of plant/responses to weather and site conditions. Years in which erratic weather conditions prevail may be expected to cause unequal plant growth responses and thus remove potential industrial activity as a sole cause of such responses. On the other hand, when high uniformity is observed among the various sites in years prior to development, this may be used as an index from which to measure any departure. As continued yearly measurements accrue, it will be possible to determine the average response that may be expected of the sagebrush plants.

The year-to-year variation in stem growth is of considerable interest when evaluating the responsiveness of this plant charasteristic to general productivity and site conditions. Growth response in 1979 was greater than any of the previous four years (Table 4.3-4). Other good years for stem growth were 1978 and 1975. Plants in Site 3 have consistently shown the longest stem growth over the five year period of monitoring, while the shortest stems measured have generally been in Site 5 and Site 6.

Table 4.3-4. A comparison of sagebrush stem growth in 1979, 1978, 1977, 1976 and 1975 at six sites on oil shale prototype lease tracts Ua and Ub.1/

Site of Measurement		1975		1976		1977		1978		1979	
Site No.	Description	Mean Stem Length	SD	Mean Stem Length	SD	Mean Stem Length	SD	Mean Stem Length	SD	Mean Stem Length	SD
1	Industrial area west Sect. 22	7.4	2.14	6.2	1.04	2.1	.35	8.4	1.76	7.6	2.0
2	Industrial area east, Sect. 22	6.9	1.12	6.16	1.63	2.0	.25	8.1	2.88	9.9	2.23
3	Section 29 west on Asphalt Wash Road	9.7	1.86	7.0	.88	4.0	1.02	10.1	2.16	9.9	2.47
4	Section 35. South of tracts	5.6	1.03	5.5	1.06	2.2	.25	6.4	1.10	8.2	2.08
5	Section 18. 3 miles east	7.2	1.31	5.4	1.17	2.8	.59	5.6	1.59	7.3	1.75
6	Section 4. North of Industrial area	6.4	1.5	4.8	1.08	2.8	.56	6.5	2.52	7.7	1.88
	Overall average	7.0		5.9		2.7		7.5		8.4	

1/ Each value is the mean length of 20 stems on 20 plants for a total of 400 observations per site in any given year.

Observations of flowering and other plant growth-development characteristics in 1979 support the relatively favorable mesurements of stem growth. The abundant flowers and seeds observed in September were not observed in previous years. Summer and fall precipitation amounts were a major factor in the improved growth environment. Even in 1975, the most favorable year of plant growth observed on the tracts, sagebrush stem growth was not as long as in 1979. The difference was probably caused by the favorable 2-week spacing of rain in the spring of 1975, but drier conditions in the late summer and fall than in 1979.

4.3.1.3.3 Results of Field Studies

A. Control of Plant Competition

The average plant survival taken in the spring and fall over three growing seasons comparing bare-root and container grown stock under three plant competition levels at the Section 6 study site are shown in Figure 4.3-10. The survival differences between the 2-year clean cultivation and control (no cultivation) treatments at the end of the third growing season are quite discernable with plant survival at the 1-year clean cultivation treatment lying between the other two treatments.

This figure suggests that three to four growing seasons or longer may be needed to determine the full establishment of plants under these arid conditions. Plants under normal competition appear to be stabilizing during the third year (1979) but there are only indications of this trend in the two cultivation treatments.

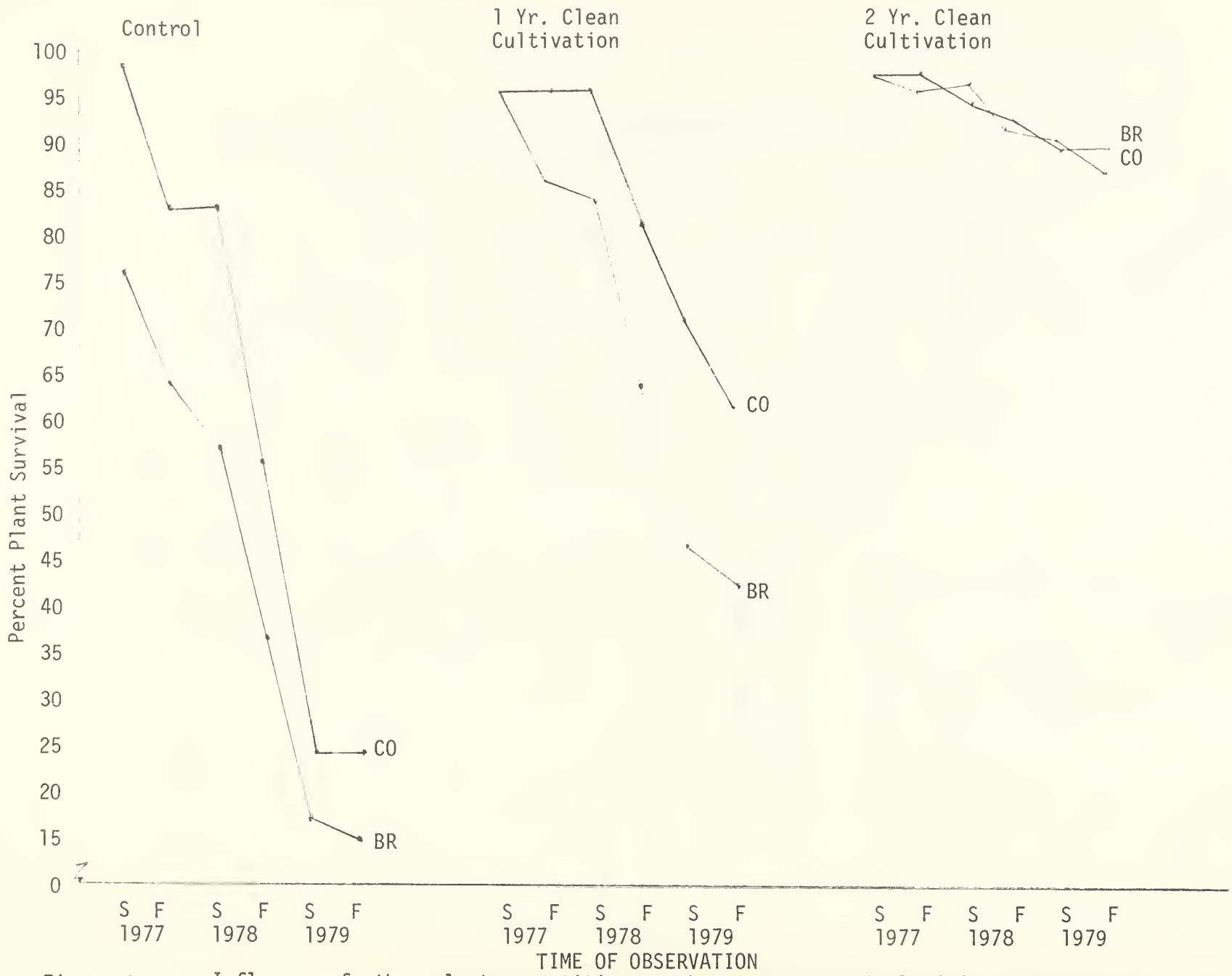


Figure 4.3-10. Influence of other plant competition on the average survival of four plant species over three growing seasons. Compared are two methods of planting bare-root (BR) and container (C) planted stock growing under three levels of annual plant competition. Date of field planting was April 5, 1977.

Plant growth showed various restrictions in height and areal cover where the plants were subjected to higher levels of competition. Generally, average plant cover following 2-years clean cultivation was twice as great as the control area (no cultivation). Under normal competition Kochia prostrata had the highest survival and ground cover levels of the four plant species evaluated.

In averaging all five species at the end of the third growing season plant survival was 72 percent under clean cultivation and only 41 percent where there was plant competition. In comparing plant survival of the four species omitting Kochia prostrata, plant survival was 70 percent under clean cultivation and only 27 percent under normal competition. Plants under clean cultivation had three times the growth cover as those growing with plant competition as shown in Table 4.3-5 at the end of three growing seasons.

In this study plants under two years of clean cultivation appeared to be fairly well stabilized in their estrablishment. Those under normal competition did not show this initial survival stability until the third year following field planting as shown in Figure 4.3-11.

B. Effect of Plant Age and Pruning Levels on Fourwing Saltbush

Survival data over two growing seasons are shown in Table 4.3-6. One year old stock, regardless of pruning level, was better than two or three year old planting stock. There is little difference between survival of two and three year old stock provided they are pruned. The more heavily pruned older stock showed slightly better survival and growth than the lightly pruned stock.

Table 4.3-5. Influence of weedy plant competition on the survival and growth expressed in height and plant cover on five shrubs. Data is the averages from six treatments and four replications at six observation periods over three years.

Species	Observation Date	Survival Control	Survival Clean Cultivation	Height Control	Height Clean Cultivation	Plant Cover Control	Plant Cover Clean Cultivation
		%	%	cm	cm	dm^2	dm^2
Greasewood	1977-Spring	100	100	14	13		
	-Fall	67	79	14	12		
	1978-Spring	58	79	18	20	1.28	2.25
	-Fall	50	79	13	23	0.65	3.38
	1979-Spring	42	79	14	26	1.65	6.81
	-Fall	37	79	22	32	3.04	5.36
Fourwing saltbush	1977-Spring	100	96	8	9		
	-Fall	75	83	9	11		
	1978-Spring	58	58	12	22	0.83	2.34
	-Fall	33	58	9	33	0.40	4.43
	1979-Spring	21	54	11	33	1.75	7.52
	-Fall	21	50	22	45	1.37	10.69
Shadscale saltbush	1977-Spring	71	92	7	9		
	-Fall	63	83	6	10		
	1978-Spring	54	83	15	20	2.34	4.77
	-Fall	33	83	12	19	1.92	5.77
	1979-Spring	29	83	17	29	3.58	12.15
	-Fall	29	83	19	32	4.29	13.69
Cuneate saltbush	1977-Spring	67	96	4	5		
	-Fall	54	83	4	5		
	1978-Spring	37	71	11	17	1.09	2.20
	-Fall	33	71	10	17	1.32	3.28
	1979-Spring	21	71	13	24	1.33	6.76
	-Fall	21	71	17	26	2.75	7.48
Kochia prostrata	1977-Spring	100	96	21	20		
	-Fall	96	92	25	25		
	1978-Spring	96	83	30	35	3.12	4.35
	-Fall	96	83	26	47	2.98	6.00
	1979-Spring	96	83	26	32	3.46	6.95
	-Fall	96	79	35	43	5.24	12.68
Average of 5 species	1979-Spring	42	74	16	29	2.35	8.04
	-Fall	41	72	23	35	3.34	9.98

Date of field transplanting - March 31, 1977 Exp. A13

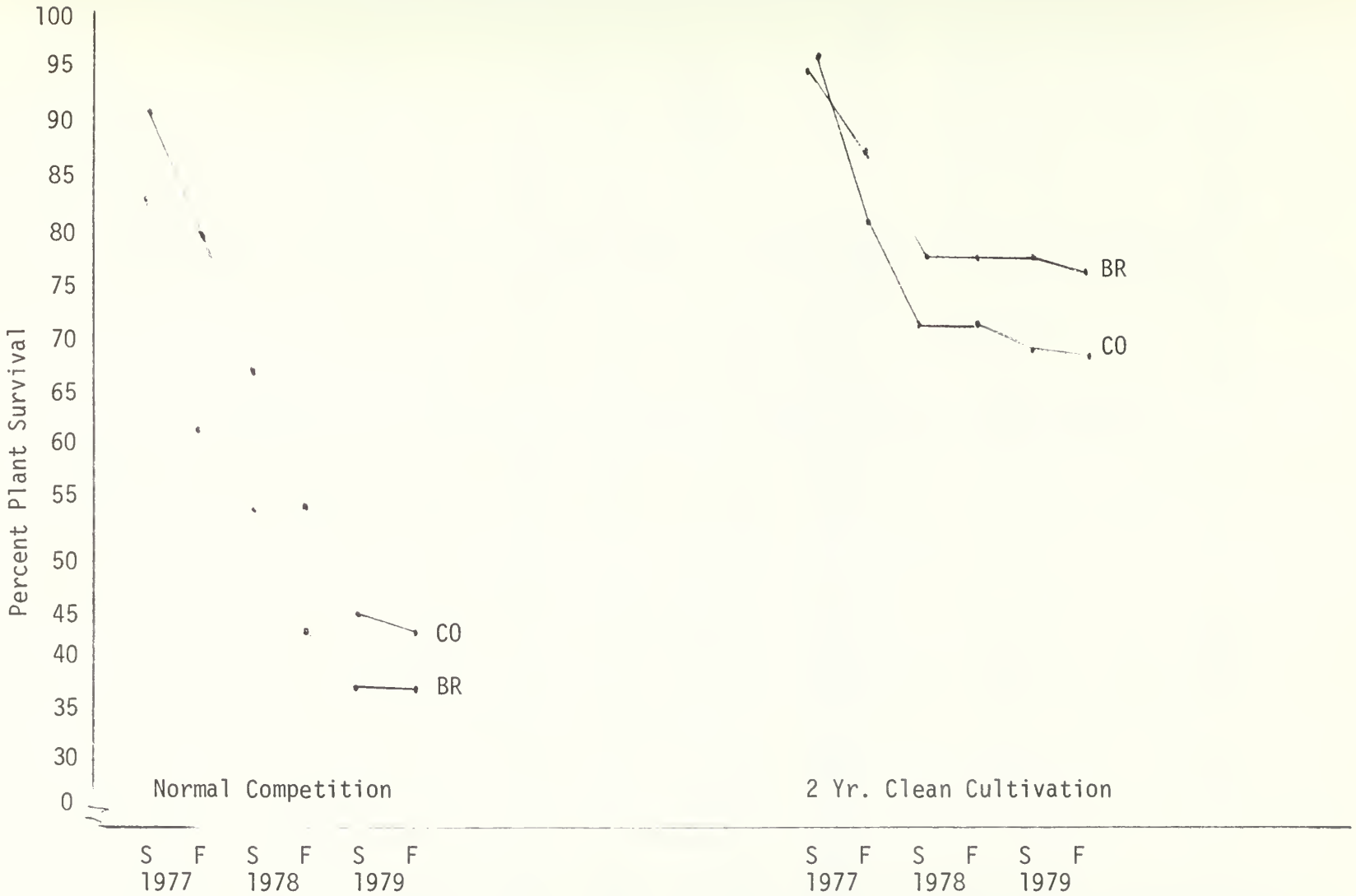


Figure 4.3-11. Average survival of five shrub species when comparing two methods of planting - bare-root (BR) and container (CO) grown stock when subjected to two levels of plant competition - normal and clean cultivation over three growing seasons. Date of field planting was March 31, 1977.

Table 4.3-6. Survival of Fourwing saltbush bare-root transplants at two locations when comparing plant age and pruning variabilities. Average of 4 replications and four plants per replication.

Plant Age Years	Pruning Treatment	Bonanza (Sect 6) 1978 June	Bonanza (Sect 6) 1978 Sept	Bonanza (Sect 6) 1979 June	Bonanza (Sect 6) 1979 Sept	Nephi Field Station 1978 June	Nephi Field Station 1978 Sept	Nephi Field Station 1979 June	Nephi Field Station 1979 Sept	Average Sept 1979 Data Both Locations
		%	%	%	%	%	%	%	%	%
One	Control	100	94	94	94	100	100	88	88	91
Two	Control	69	69	63	63	69	69	69	69	66
Three	Control	81	81	63	63	38	38	38	38	50
One	Light	100	100	94	94	100	100	100	100	97
Two	Light	75	75	69	69	69	69	69	69	69
Three	Light	88	88	81	81	75	75	75	75	78
One	Heavy	100	100	94	94	100	100	100	100	97
Two	Heavy	100	100	94	88	56	56	50	50	69
Three	Heavy	94	88	88	88	75	75	75	75	81
Comparing the average of each plant age (including the three treatments)										
One		100	98	94	94	100	100	96	96	95
Two		81	81	75	73	65	65	63	63	68
Three		88	85	77	77	63	63	63	63	70
Comparing the average of two and three year old plants for each pruning treatment										
Two & 3 yr	Control	75	75	63	63	53	53	53	53	58
Two & 3 yr	Light	81	81	75	75	72	72	72	72	73
Two & 3 yr	Heavy	97	94	91	88	66	66	63	63	75

A second study on plant age (at planting) as a factor in field survival dealt with two types of relatively young planting materials (ages 8, 16, and 24 weeks before field planting). Table 4.3-7 summarizes the study results. Apparently, plants can be field transplanted as young as 8 weeks with good survival results. Seedling survival was slightly greater than rooted stem cuttings. Fourwing saltbush survival was greater than cuneate saltbush, primarily because survival of the 16-week old cuneate cuttings was poor.

Table 4.3-7 Influence of plant age on survival after outplanting for fourwing saltbush and cuneate saltbush seedlings and rooted stem cuttings. Survival was measured 15 months after outplantings.

Species Propagation	Age of Plant Materials at Time of Outplanting (weeks)			
	8	16	24	$\bar{X}$
Fourwing saltbush				
seedlings	90	90	90	90
cuttings	100	100	100	100
Cuneate saltbush				
seedlings	100	100	90	97
cuttings	90	50	90	77
$\bar{X}$	95	85	93	

C. Plant Survival and Growth Comparing Season and Planting Methods

Table 4.3-8 and Figures 4.3-12 and 4.3-13 show the average survival of nine shrub species comparing methods of propagation and planting season, respectively. There is an indication that shrub survival began to stabilize during the third growing season. During 1979, the shrubs appeared to be in equilibrium and fully established. These figures show graphically that plants should be observed at least 3 to 4 years when studying survival under arid conditions. The difference among the three sites are assumed to be due to variations in soil, annual plant competition, and rodents. Plant competition and rodent damage at drill site G-3 and Section 6 study sites were greater than at the drill site G-17 study site.

Plant growth expressed as plant cover for the nine shrubs are shown in Table 4.3-9. There was no particular difference in growth due to season of planting or between bare-root and container methods of planting as shown in Figures 4.3-14 and 4.3-15. While direct seeding of shrubs is not dependable for rehabilitating an arid site, those seedlings still alive in 1979 appear to be well established (see Table 4.3-10).

D. Plantings in Processed Shale and Soil Over Shale-Filled Pits

This study continues from the revegetation study of 1976-77. The salt tolerant chenopods shown the best survival in the shrub study and seepweed and *Kochia prostrata* are the only two species living in the grass-forb study.

There were numerous halogeton seedlings in June, 1979, scattered where soil overlaid the shale and quite a few growing in the straight shale. Those in the shale were in most cases growing where the soil core

Table 4.3-8. Survival comparison in transplanting nine shrub species using two methods - bare-root and container-grown stock - at three locations and at two seasons of planting - Fall 1975 and Spring 1976. Observations for comparison are shown for spring and fall survival over a four-year period. Data are averages from three treatments and from four replications at each location. Data shows percent survival, 2, 5, 14, 17, 26, 29, 38, and 41 months following the final planting.

Species and Treatment		Drill Hole G-3								Drill Hole G-17								Section 6							
		1976		1977		1978		1979		1976		1977		1978		1979		1976		1977		1978		1979	
		June	Oct	June	Sept	June	Sept	June	Sept	June	Oct	June	Sept	June	Sept	June	Sept	June	Oct	June	Sept	June	Sept	June	Sept
		%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Greasewood	FBR	100	92	92	92	92	92	92	92	33	33	33	33	33	33	33	33	50	42	42	33	33	33	33	33
	SBR	75	75	75	75	75	75	75	75	83	83	83	83	83	58	50	50	92	33	25	25	25	25	25	25
	FCO	100	100	100	100	100	100	100	100	92	92	92	83	83	83	83	83	100	83	75	75	75	75	67	67
	SCO	100	100	100	100	100	100	100	100	83	83	83	83	83	83	83	83	100	67	67	58	58	58	58	58
Fourwing saltbush	FBR	33	33	17	17	17	17	17	17	33	33	33	33	25	25	25	25	0	0	0	0	0	0	0	0
	SBR	100	100	92	83	83	83	83	83	100	100	75	75	75	75	75	75	100	100	100	100	100	100	100	100
	FCO	67	67	67	67	67	67	67	67	75	67	67	58	58	58	58	58	86	58	58	58	58	58	50	50
	SCO	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	92	92	92	92	92	92	92
Shadscale saltbush	FBR	67	50	25	9	0	0	0	0	83	67	58	58	50	42	42	42	83	83	83	83	83	83	83	83
	SBR	100	50	17	17	8	8	8	8	100	100	83	83	67	58	58	58	100	100	100	100	100	100	100	100
	FCO	83	58	33	25	0	0	0	0	83	83	75	75	75	75	67	67	100	92	83	75	75	67	67	67
	SCO	100	58	58	42	25	25	25	25	83	83	67	67	67	67	42	42	100	92	92	92	92	83	83	83
Cuneate saltbush	FBR	75	50	17	9	0	0	0	0	83	67	67	67	50	42	42	42	75	58	58	58	58	58	58	58
	SBR	92	42	25	17	0	0	0	0	100	100	100	100	100	100	75	75	92	92	83	83	75	75	50	50
	FCO	75	50	25	9	0	0	0	0	75	67	67	67	67	67	58	58	83	58	58	58	50	50	33	33
	SCO	92	50	0	0	0	0	0	0	100	92	83	75	75	75	75	67	100	92	92	92	92	92	75	67
Winterfat	FBR	58	50	42	42	42	42	42	42	50	50	50	50	50	25	25	25	75	75	58	58	58	50	50	50
	SBR	83	75	75	75	67	67	58	58	100	100	92	92	92	83	83	83	83	75	50	50	42	42	33	33
	FCO	100	83	75	75	75	75	58	58	75	75	67	67	67	67	67	67	83	67	8	8	8	8	8	8
	SCO	100	100	92	92	83	83	83	83	83	83	75	75	75	75	75	75	100	100	100	100	92	92	58	58
Greenes rabbitbrush	FBR	92	92	92	75	75	58	58	58	75	67	50	50	50	50	50	50	75	50	25	0	0	0	0	0
	SBR	100	100	100	100	100	83	67	67	100	83	75	75	75	75	75	75	83	42	0	0	0	0	0	0
	FCO	75	75	75	67	67	67	42	42	100	100	100	100	83	83	83	83	67	25	25	0	0	0	0	0
	SCO	100	100	100	83	75	75	75	75	100	100	100	100	100	100	100	100	100	8	0	0	0	0	0	0
Black sagebrush	FBR	92	92	92	92	92	75	75	75	100	92	83	83	83	83	83	83	100	50	0	0	0	0	0	0
	SBR	100	100	100	92	92	83	67	67	92	92	92	92	92	83	83	75	100	58	8	0	0	0	0	0
	FCO	83	83	83	83	83	83	83	83	100	100	100	100	100	100	100	100	100	67	25	25	17	8	0	0
	SCO	100	92	92	92	92	92	83	83	100	100	92	92	92	92	92	92	100	25	0	0	0	0	0	0
Big sagebrush	FBR	67	67	67	67	67	67	67	67	100	83	83	83	83	67	67	67	83	75	67	58	50	50	25	25
	SBR	100	100	100	100	100	100	83	83	100	100	100	100	100	92	92	92	50	17	17	8	8	8	8	8
	FCO	100	100	100	100	100	100	83	83	100	100	100	100	100	100	100	100	92	92	83	83	58	50	33	33
	SCO	100	100	83	83	83	83	75	75	100	100	92	92	92	83	83	83	92	50	8	8	0	0	0	0
Spreading rabbitbrush	FBR	92	83	83	83	83	67	50	42	83	58	58	58	58	42	25	25	83	75	67	8	8	0	0	0
	SBR	92	75	50	8	8	8	0	0	100	75	67	50	50	42	25	25	100	75	75	0	0	0	0	0
	FCO	100	92	67	58	58	42	17	17	50	50	50	50	50	50	25	25	100	100	92	8	8	0	0	0
	SCO	100	83	75	42	42	33	17	17	100	92	83	75	75	67	58	58	92	58	42	0	0	0	0	0
Season of Planting & Propagation Method	FBR	75	68	59	54	52	46	45	44	71	61	57	57	54	45	44	44	69	56	44	33	32	30	28	28
	SBR	94	80	70	63	59	56	49	49	97	93	85	83	82	74	68	68	89	66	51	41	39	39	35	35
	FCO	87	79	69	65	61	59	50	50	83	82	80	78	76	76	71	71	90	71	56	43	39	35	29	29
	SCO	99	87	78	70	67	66	62	62	94	93	86	84	84	82	79	78	98	65	55	49	47	46	41	40
Season of Planting	FBR+CO	81	73	64	60	57	53	47	47	77	71	69	68	65	61	57	57	80	64	50	38	36	33	28	28
	SBR+CO	96	83	74	67	63	61	56	56	96	93	86	84	83	78	74	73	94	65	53	45	43	43	38	37
Propagation Method	BR	84	74	65	60	56	51	47	46	84	77	71	70	68	60	56	56	79	61	48	37	36	35	31	31
	CO	93	83	74	68	64	63	56	56	89	87	83	81	80	79	75	75	94	68	56	46	43	41	35	34

Date of seeding: Fall - November 13-14, 1975
Spring - March 23, 1976

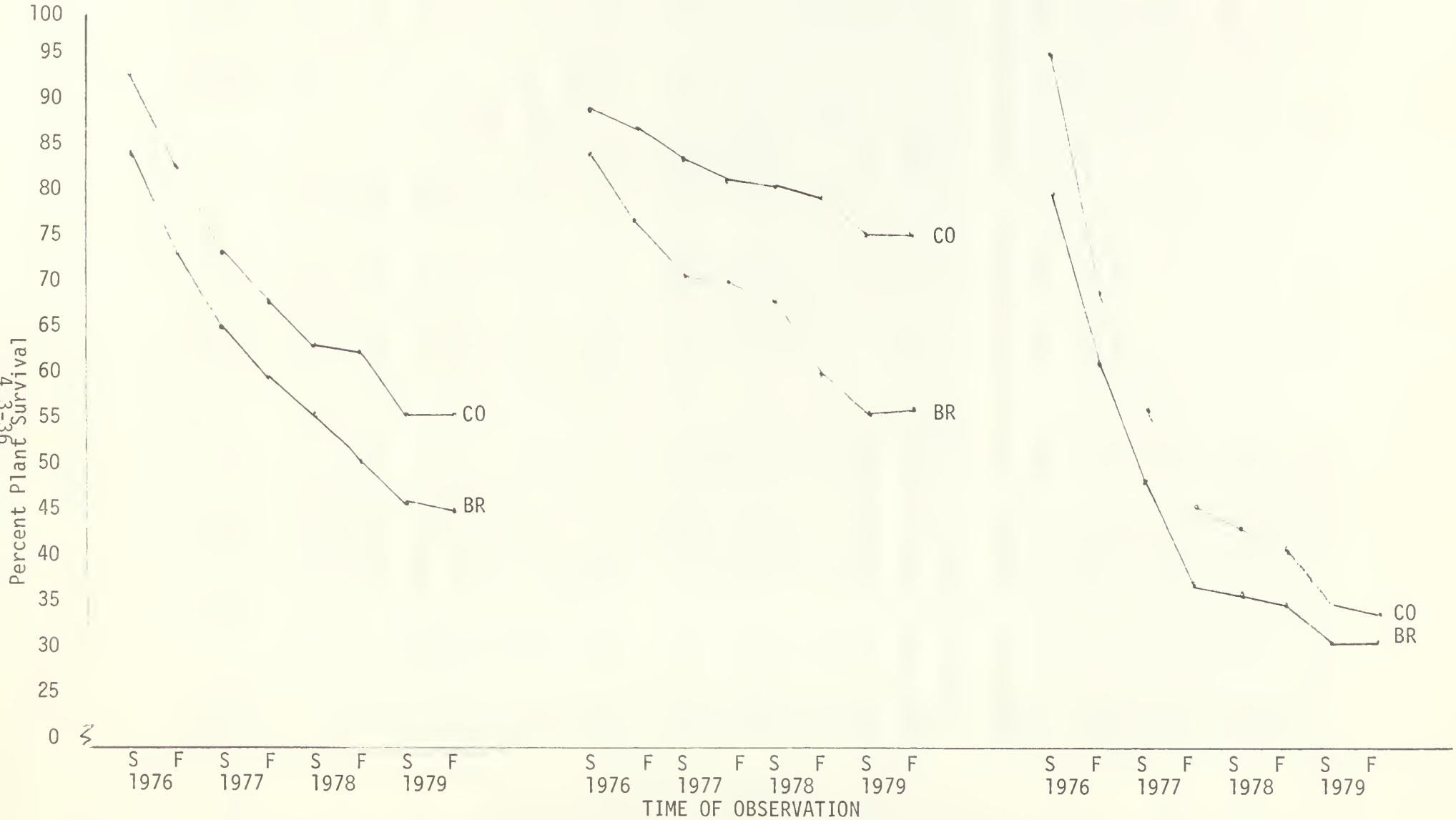


Figure 4.3-12. Average survival of nine shrub species comparing two methods of propagation, bare-root (BR) and container (CO) grown stock at three locations. The two seasons of planting, spring and fall are averaged within the data.

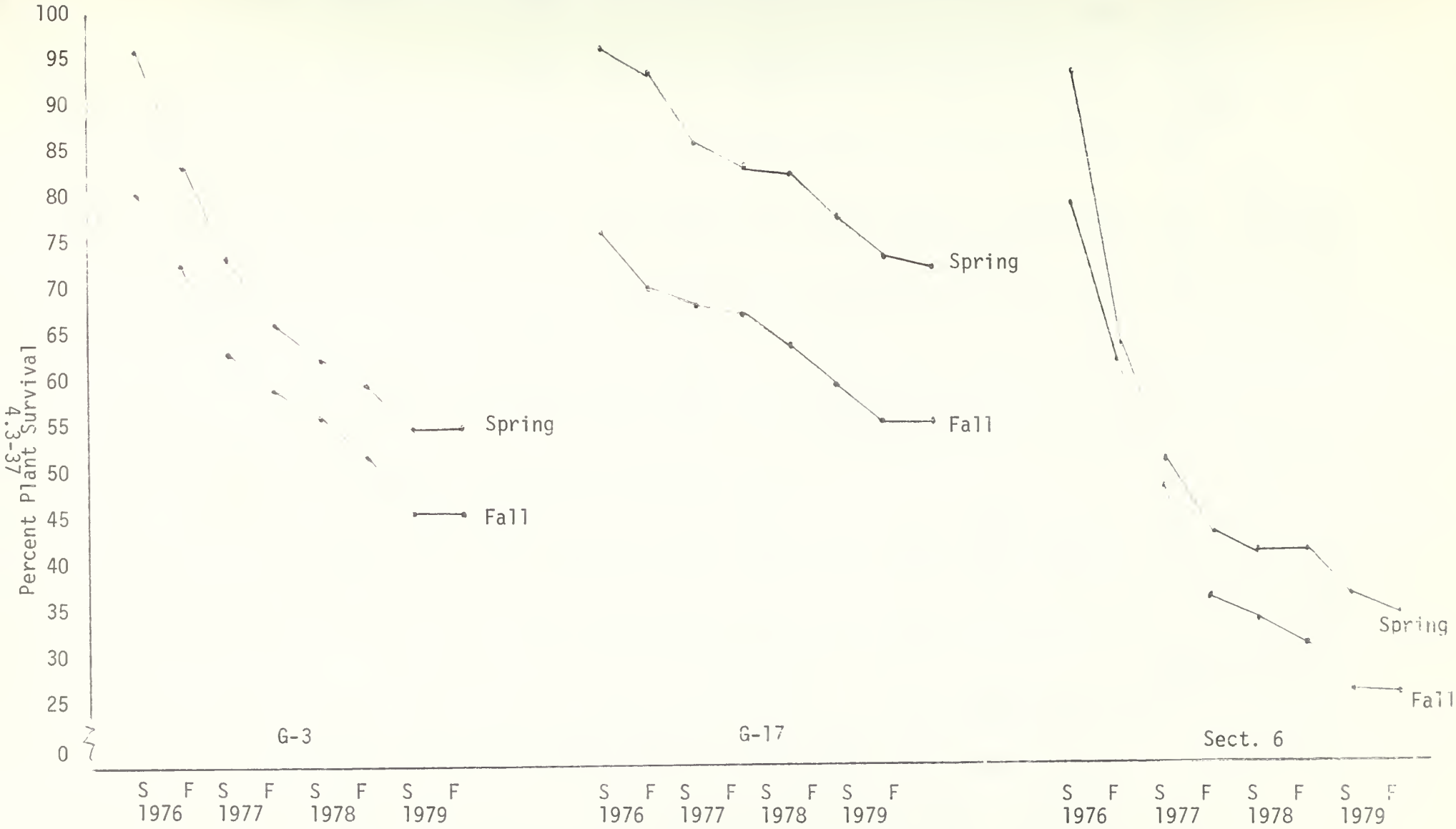


Figure 4.3-13. Average survival of nine shrub species comparing seasons of planting, Fall (F) and Spring (S) at three locations. Two methods of propagation, bare-root and container are averaged within the data.

Table 4.3-9. Plant growth comparisons from nine shrubs using two methods of transplanting - bare-root and container-grown stock - at three locations and at two seasons of planting - Fall 1975 and Spring 1976. Data is shown for spring and fall observations during a two year period. Data are averages of three treatments and four replications at each location and expressed in square decimeters.

Species and Treatment		Drill Hole G-3				Drill Hole G-17				Section 6			
		1978		1979		1978		1979		1978		1979	
		June	Sept	June	Sept	June	Sept	June	Sept	June	Sept	June	Sept
		dm^2	dm^2	dm^2	dm^2	dm^2	dm^2	dm^2	dm^2	dm^2	dm^2	dm^2	dm^2
Greasewood	FBR	4.42	5.57	17.03	14.70	2.87	2.58	2.25	4.80	1.31	1.62	2.92	11.15
	SBR	3.27	3.36	12.67	11.20	0.98	1.79	1.72	2.50	1.25	2.50	3.58	12.00
	FCO	3.33	3.63	12.46	12.90	2.53	2.20	1.74	2.60	1.90	1.78	2.25	6.17
	SCO	3.07	3.46	10.92	9.60	2.28	2.44	2.42	4.20	1.12	9.00	1.47	5.07
Fourwing saltbush	FBR	15.30	17.00	6.50	9.50	1.90	3.44	2.25	5.00	0	0	0	0
	SBR	22.07	23.76	35.33	37.57	9.24	13.81	7.80	21.30	13.94	13.78	8.51	30.40
	FCO	18.00	20.80	33.60	40.27	7.29	9.67	4.14	19.00	6.12	7.03	3.92	27.50
	SCO	16.48	18.63	22.79	26.53	13.28	19.75	7.33	20.2	6.12	7.73	1.44	13.40
Shadscale saltbush	FBR	0	0	0	0	5.26	3.39	4.28	6.30	3.15	3.05	3.50	6.10
	SBR	11.00	12.50	7.50	3.50	6.98	7.01	6.17	10.70	5.07	5.35	4.98	8.60
	FCO	0	0	0	0	9.00	9.56	8.33	13.00	4.14	5.18	4.50	7.90
	SCO	11.30	10.63	21.63	19.10	12.97	13.04	12.06	21.20	2.46	2.62	2.85	5.80
Cuneate saltbush	FBR	0	0	0	0	10.64	11.25	8.25	24.90	1.32	1.40	1.08	4.10
	SBR	0	0	0	0	5.18	4.41	5.75	8.90	1.67	1.84	1.67	4.50
	FCO	0	0	0	0	11.35	7.74	9.17	15.40	2.47	2.56	3.38	13.50
	SCO	0	0	0	0	8.04	9.23	8.94	16.30	1.75	1.74	1.41	5.20
Winterfat	FBR	3.29	3.13	6.42	4.30	1.46	1.75	1.33	1.80	0.87	0.80	0.96	2.00
	SBR	3.92	3.14	8.72	4.00	1.91	2.13	1.39	1.70	0.50	0.42	0.92	1.75
	FCO	4.02	3.36	8.72	5.30	4.25	3.21	1.42	2.20	1.00	0.75	1.50	1.50
	SCO	3.26	3.11	6.79	3.80	4.18	4.17	2.69	3.60	0.89	0.77	1.81	4.57
Greenes rabbitbrush	FBR	4.71	5.09	15.67	11.06	2.25	2.44	1.60	1.90	0	0	0	0
	SBR	2.92	3.71	7.67	4.55	1.66	0.80	1.07	0.90	0	0	0	0
	FCO	2.56	2.93	7.25	3.92	2.93	3.04	1.83	2.40	0	0	0	0
	SCO	2.90	2.98	6.22	4.28	3.86	3.56	2.67	5.80	0	0	0	0
Black sagebrush	FBR	2.90	2.57	6.44	4.20	1.90	1.57	2.11	2.90	0	0	0	0
	SBR	2.51	2.25	5.45	3.00	2.42	2.23	2.29	3.40	0	0	0	0
	FCO	3.00	3.11	6.54	4.00	4.10	4.42	3.42	4.50	0.55	0.50	0	0
	SCO	1.61	1.52	3.09	2.00	1.28	1.19	1.60	2.10	0	0	0	0
Big sagebrush	FBR	4.64	5.04	12.38	6.80	2.61	2.81	3.37	5.20	1.06	0.88	1.32	2.12
	SBR	3.14	2.95	7.93	5.00	3.02	2.58	2.74	4.00	1.50	1.75	1.50	2.00
	FCO	6.27	5.79	12.00	9.50	6.50	6.19	5.21	9.20	1.77	1.99	2.33	3.83
	SCO	2.16	2.10	4.82	3.40	1.83	1.83	2.44	3.00	0	0	0	0
Spreading rabbitbrush	FBR	3.37	5.39	9.31	12.30	1.12	1.13	1.00	2.20	0.10	0	0	0
	SBR	1.00	0.10	0	0	1.00	1.34	0.85	1.70	0	0	0	0
	FCO	1.46	1.88	5.50	4.50	2.50	1.90	2.13	3.50	2.00	0	0	0
	SCO	2.81	2.91	8.50	8.00	1.89	1.77	1.17	1.80	0	0	0	0
Season of Planting & Propagation Method	FBR	5.52	6.26	10.54	8.98	3.33	3.37	2.94	6.11	1.30	1.55	1.96	5.09
	SBR	6.23	6.47	12.18	9.83	3.60	4.01	3.31	6.12	3.99	4.27	3.53	9.88
	FCO	5.52	5.93	12.30	11.48	5.61	5.33	4.15	7.98	2.49	2.83	2.98	10.07
	SCO	5.45	5.67	10.60	9.59	5.51	6.33	4.59	8.69	2.47	4.37	1.80	6.81
Season of Planting	FBR+CO	5.52	6.09	11.42	10.23	4.47	4.35	3.55	7.04	1.98	2.30	2.51	7.81
	SBR+CO	5.84	6.07	11.34	9.70	4.56	5.17	3.95	7.41	3.30	4.32	2.74	8.48
Propagation Method	BR	5.90	6.37	11.36	9.41	3.47	3.69	3.12	6.12	2.65	3.04	2.81	7.70
	CO	5.48	5.79	11.39	10.47	5.56	5.83	4.37	8.33	2.48	3.47	2.44	8.59

Date of seeding: Fall - November 13-14, 1975
Spring - March 23, 1976

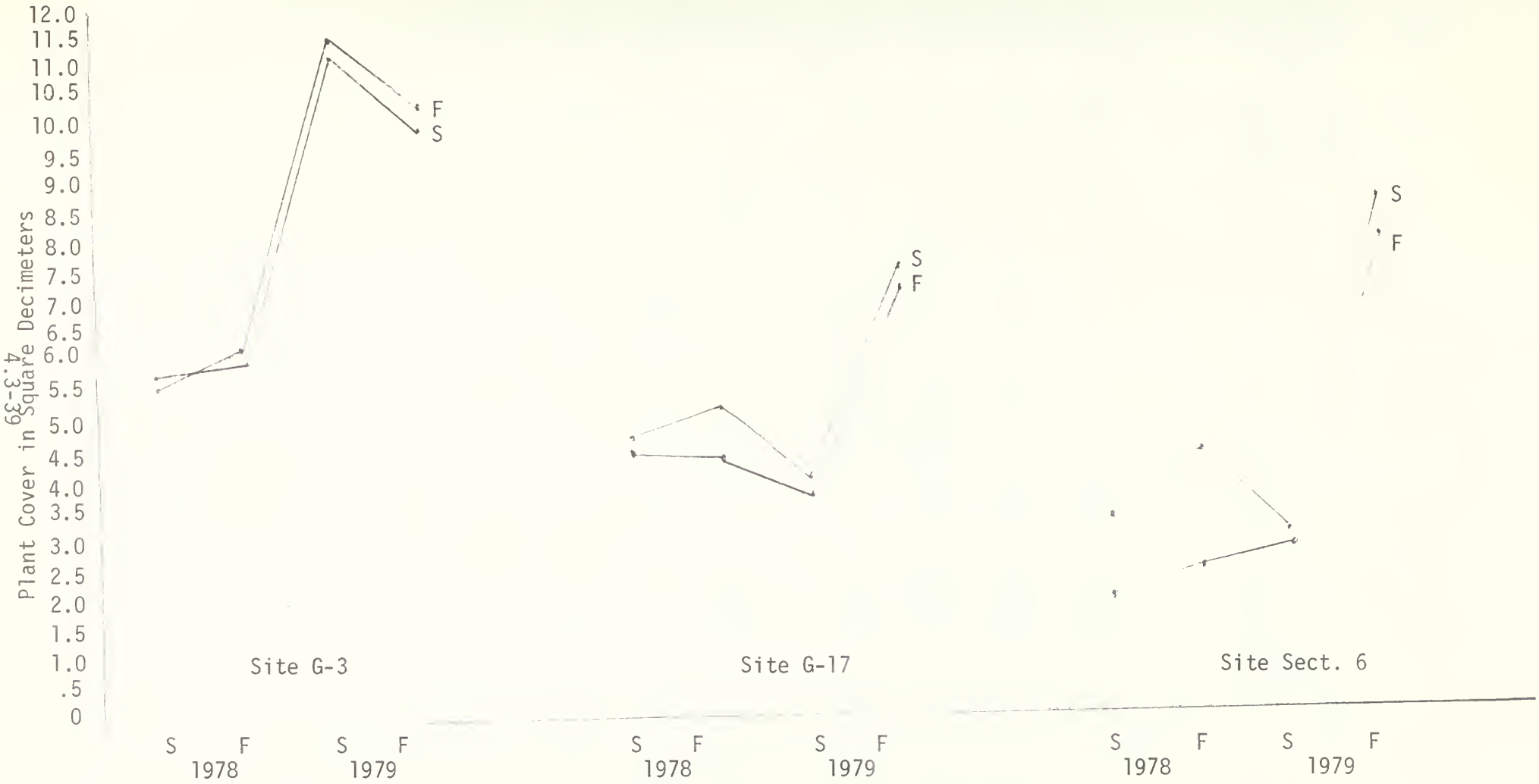


Figure 4.3-14. Average plant growth of nine shrub species comparing season of planting Fall (F) and Spring (S) at three locations. Two methods of propagation -- bare-root and container are averaged within the data.

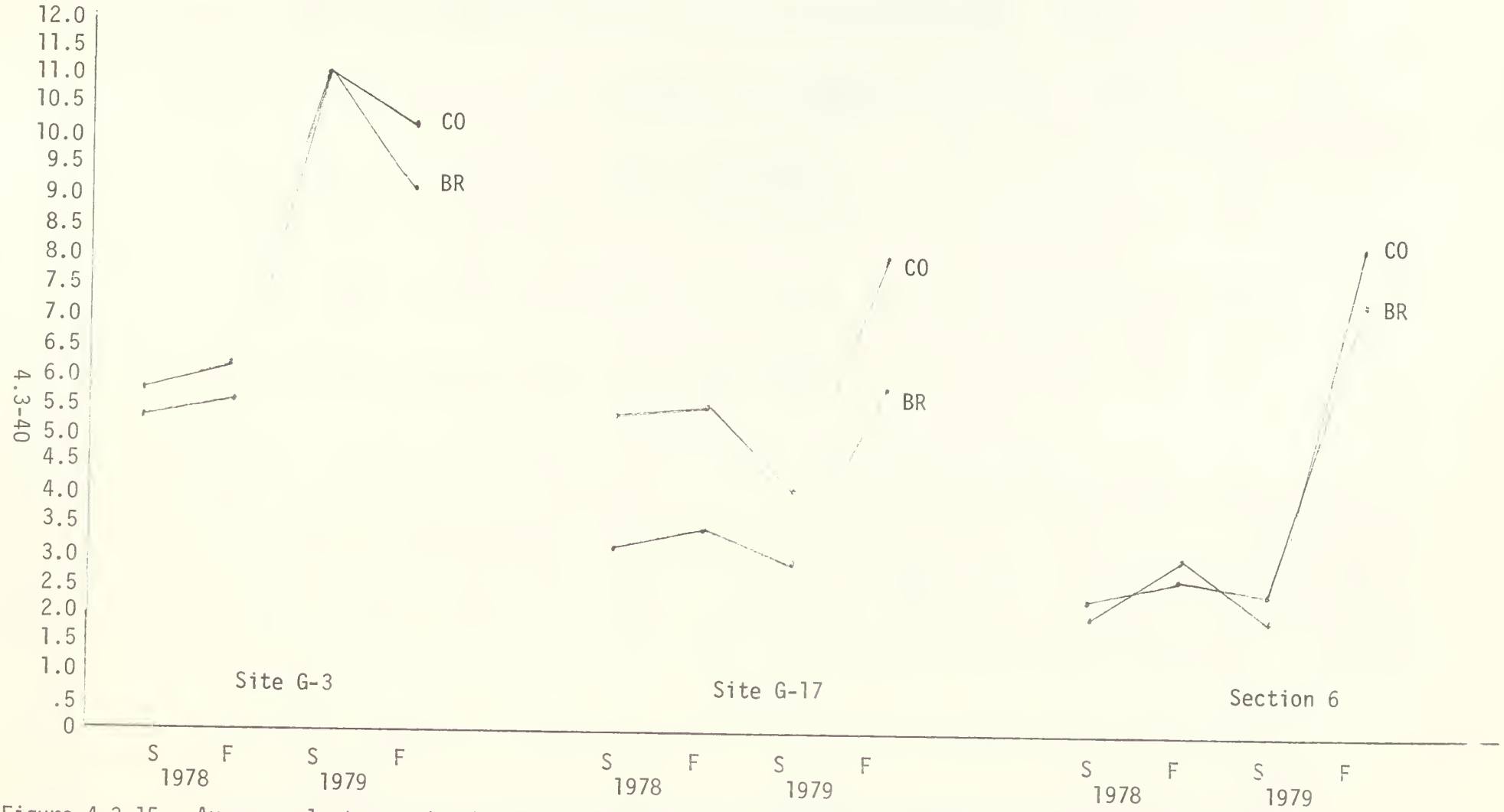


Figure 4.3-15. Average plant growth of nine shrub species comparing two planting methods, bare-root (BR) and container (CO) grown stock during the third and fourth growing seasons following planting. Two seasons of plantin fall and spring are averaged in the data.

Table 4.3-10. Field survival of five grass species after 3 or 4 years[1] in three planting sites. Plants were planted as bare-root or container-grown stock in fall 1975 and spring 1976.

Species	Treatment	Drill Hole G-3 June 1976	June 1977	June 1978	Drill Hole G-17 June 1976	June 1977	June 1978	June 1979[1]	Section 6 June 1976	June 1977	June 1978
		%	%	%	%	%	%	%	%	%	%
Indian ricegrass	FBR	33	17	0	58	25	25	17	0	0	0
	SBR	83	83	75	92	83	75	33	83	22	0
	FCO	75	75	75	75	75	75	50	50	25	17
	SCO	83	83	83	42	17	8	8	100	42	33
Needle & thread grass	FBR	58	25	8	83	42	42	33	8	0	0
	SBR	67	67	67	83	58	58	33	50	8	8
	FCO	67	58	58	83	42	42	25	100	8	0
	SCO	100	100	83	92	92	92	58	92	0	0
Fairway crested wheatgrass	FBR	83	42	42	75	17	17	17	58	8	0
	SBR	100	92	83	100	92	67	33	100	50	8
	FCO	67	67	67	100	83	75	75	100	42	17
	SCO	83	83	83	92	75	75	67	83	25	0
Western wheatgrass	FBR	100	83	58	83	67	67	58	92	75	33
	SBR	83	83	67	92	67	67	42	100	100	58
	FCO	100	100	100	100	92	92	92	100	92	83
	SCO	92	75	75	100	92	92	83	92	75	58
Bluebunch wheatgrass	FBR	75	58	42	67	25	25	8	92	17	0
	SBR	75	58	50	75	58	42	25	100	33	0
	FCO	83	83	50	83	83	83	67	92	33	0
	SCO	100	92	83	83	67	67	67	92	17	0
Season of Planting & Propagation Method											
	FBR	69.8	45.0	30.0	73.2	35.2	35.2	26.6	50.0	20.0	6.6
	SBR	81.6	76.6	68.4	88.4	71.6	61.8	33.2	86.6	42.6	14.8
	FCO	78.4	76.6	70.0	88.2	75.0	73.4	61.8	88.4	40.0	23.4
	SCO	91.6	86.6	81.4	81.8	68.6	66.8	56.6	91.8	31.8	18.2
Season of Planting											
	FBR+CO	74.1	60.8	50.0	80.7	55.1	54.3	44.2	69.2	30.0	15.0
	SBR+CO	86.6	81.6	74.9	85.1	70.1	64.3	44.9	89.2	37.2	16.5
Propagation Method											
	BR	75.7	60.8	49.2	80.8	53.4	48.5	29.9	68.3	31.3	10.7
	CO	85.0	81.6	75.7	85.0	71.8	70.1	59.2	90.1	35.9	20.8

[1] Due to contamination from natural seedlings, observation data for June 1979 was obtained only from the G-17 location.

remained from where a plant had died. This was more noticeable in the shrub study. A few cheatgrass plants were found growing in the soil over shale treatments. Natural weathering of the shale seems to be conducive in initiating physical and chemical changes allowing seed germination and growth of some annual plants, thereby starting environmental changes.

E. Water Harvesting Basin Study

Of the 40 basins originally planted in 1976 with fourwing saltbush, 16 plants of 20 in the small basins and 5 plants of 20 in the large basins were alive in the fall of 1979. Poor large basin design resulted in the harvested water percolating into the soil too distant from the transplant. This allowed for an abundant growth of annuals, particularly halogeton, which utilized the moisture rather than making it available to the saltbush. The abundant growth of annual competition also made an ideal habitat for rodents which severely grazed the saltbushes. This condition did not occur in the small basins as the annuals remained relatively small.

F. Mycorrhizae Studies

Mycorrhizae plants had a low percentage of infection (approximately 8.1%) and these were mainly strains of hypae and peletons, with very few vessicles and no arbuscubes. The control plants had less than 1.0% infection by mycorrhizae fungi. Table 4.3-11 shows the results of this study.

Table 4.3-11. Effect of mycorrhizal innoculation on field performance of *Atriplex canescens* container-growth seedlings.

Treatment	Plant Survival %	Mean Increase in Plant Height(cm) 10/6/78	Mean Increase in Plant Height(cm) 9/7/79	Mean Cover % (m^2 Quadrat) 9/7/79	Total Mean Biomass(g) 9/7/79
Mycorrhizal	100	2.80	22.0	30.0	28.02
Control	80	2.40	20.00	8.6	11.02

In a companion study five mycorrhizal innoculated and five non-innoculated cuttings were grown in the green house until ready for outplanting. The ten plants were transplanted to a sterile subsoil band of an oil shale filled trench.

Mycorrhizal plants had 2.5% infection and these were only associatd hyphae and a few peletons. Control plants had zero infection by mycorhizal fungi (Table 4.3-12).

Table 4.3-12. Plant performance of mycorrhizal treated cuttings of *Atriplex canescens* in a narrow soil trench in Paraho shale.

Treatment	Plant Survival %	Mean Increase in Plant Height(cm) 10/6/78	Mean Increase in Plant Height(cm) 9/7/79	Mean Cover % (m^2 Quadrat) 9/7/79	Total Mean Biomass(g) 9/7/79
Mycorrhizal	100	1.40	13.50	5.0	7.94
Control	80	0.60	6.90	1.6	2.96

Low infection rates on mycorrhizal plants in both shale and soil may be due in part to difficulties in removal of tertiary roots from the growing media at the time of harvest. The encouraging results in plant height, cover, and biomass indicate the potential value of mycorrhizal innoculation.

G. Endangered Species Survey

In July, 1979, Professor Arthur Holmgren, Emeritus Taxonomist of the Intermountain Herbarium made a detailed survey of the entire Southam Canyon area on Tract Ua. Professor Holmgren did not locate any endangered plant species in this study area.

4.3.2 Terrestrial Vertebrates

Terrestrial vertebrates (amphibians, reptiles, birds, and mammals) have been monitored for the past five years on the Federal Oil Shale Lease Tracts Ua/Ub in Utah (1974-1979). The tracts are located in the Uinta Basin bounded by the Uinta and Wasatch mountains, the Roan Cliffs and the Douglas Creek Arch along the Colorado-Utah border. The tracts are bounded by the White River, Asphalt Wash, and Hell's Hole Canyon covering 16 square miles of variable desert landscape. The following discussion places in perspective data collected during both the Baseline Monitoring Program and the Interim Monitoring Program which spanned five years of drastic climatic change ranging from desert bloom to drought. The work described in the following sections was conducted by Dr. C. V. Grant of Bio-Resources, Inc.

4.3.2.1 Objectives. The primary objectives of the Baseline and Interim Programs were to follow and analyze the trends in terrestrial vertebrate populations and meet the requirements of the lease stipulations for pre-mining environmental information. The specific requirements were:

1. a species inventory
2. spatial distribution of species (by vegetation community)
3. temporal distribution of species (by seasons)
4. population dynamics (abundance and density)
5. interrelationships of vertebrates to their biotic and abiotic environment.

A series of related objectives stemmed from the above:

1. Establish on an annual basis, the limits of vertebrate density and abundance.
2. Define the important vegetation communities (habitats) for vetebrates.

3. Define the important seasons for the vertebrates.

4. Establish which habitats and seasons are critical for:

   a. economically important species (game and furbearers),

   b. the threatened and endangered species,

   c. the migratory species.

5. Define which areas are important for egress and ingress to the tracts.

These objectives aid in establishing criteria for monitoring the vertebrates during tract development and mining operation and in establishing criteria for reclaiming and rehabilitating the vertebrate populations on the tracts.

4.3.2.2 Methods. Vertebrate sampling was keyed to the four primary vegetation communities (Figure 4.3-16). All vertebrates encountered on or near the tracts were identified to establish a species inventory. Two sampling sites were placed in each plant community to determine spatial distribution, abundance, and density. The vertebrates were sampled for two weeks in February, April, June, August, and October to determine temporal distribution.

The sampling methods used are fully described in the 1978 Environmental Programs Progress Report. The following is a very brief summary of those methods.

1. Mammals - Three techniques were used to study the mammals, including flushing transects, trapping, and mist netting. Eight flushing transects, each 1 kilometer in length, were established. Sherman live traps were arrayed in a 165 meter square grid in each of the vegetation types. Mist netting was used in the bat sampling program.

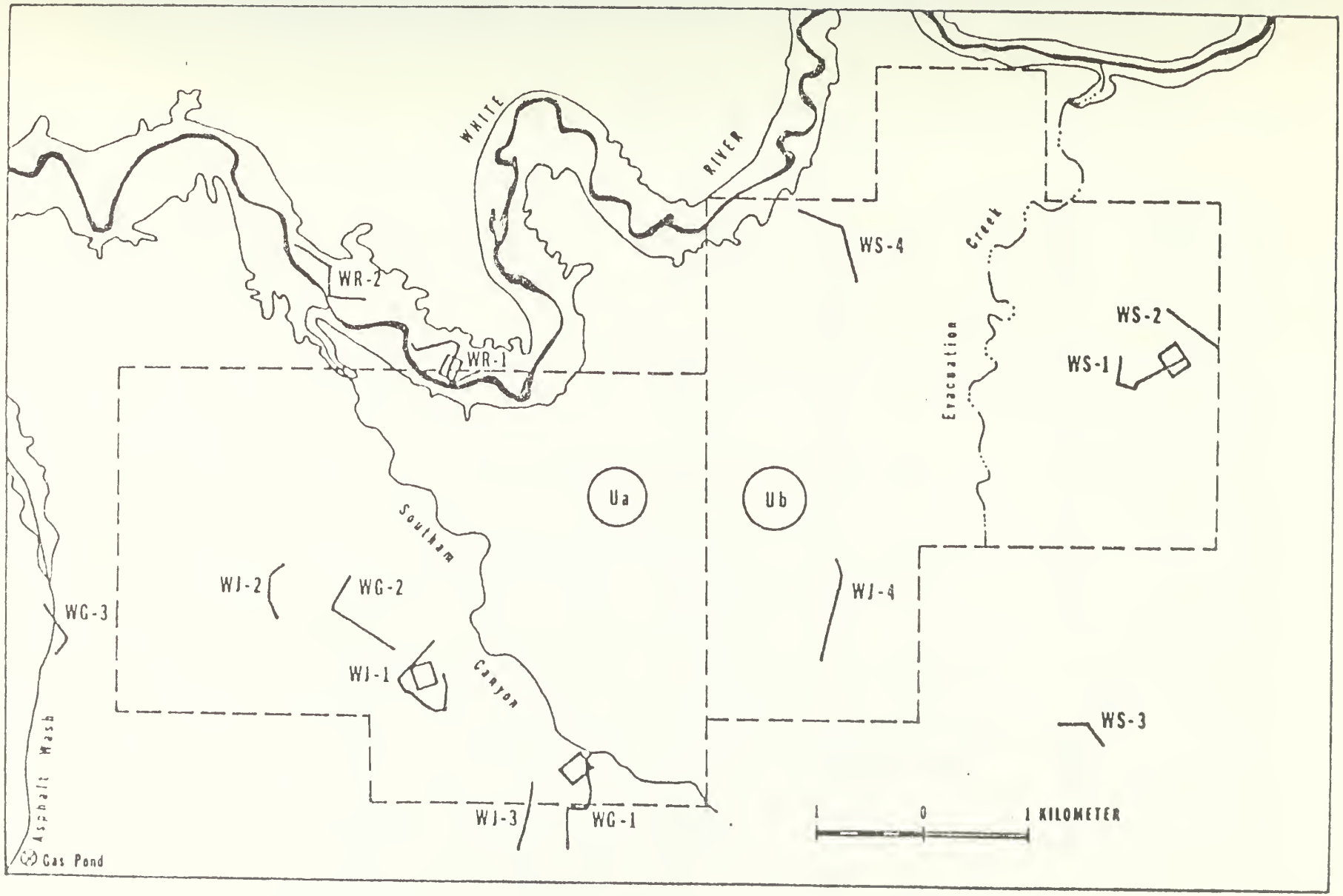


Figure 4.3-16. Location of flushing transects, large rodent trap grids, and mist-netting site used for terrestrial vertebrate monitoring on the Utah Oil Shale Tracts.

2. Birds - Flushing transects were used to sample avial populations.

3. Reptiles - Flushing transects during June and August were used to sample reptile communities.

4. Amphibians - "Opportunistic" sampling was employed.

4.3.2.3 Data Results

Mammals

1. CHIROPTERA

Insectivorous bats, including those species found on the Oil Shale Tracts, are generally opportunistic foragers exploiting locally abundant food, primarily insects. Bats may be active all year in warmer climates, but throughout most of North America their activity is greatest during the warmer months (O'Farrell et al. 1967, O'Farrell & Bradley 1970). Although largely nocturnal, some species begin foraging before dark and others forage in the dawn light. Foraging activity corresponds to insect activity (Black 1974), which is influenced by physical factors in the environment. Temporally, peak nocturnal insect activity occurs within a few hours of sunset; this is also when bat activity is greatest (Brown 1968). Spatially, bat activity in arid areas is concentrated where insects are abundant, usually near water (Fenton 1970).

Eleven species of bats were captured at the Asphalt Wash Pond. Table 4.3-13 discusses the roosting preferences, and Table 4.3-14 discusses the habitat preferences of the bat species found on the tracts.

Table 4.3-15

Roosting preferences of bat species found at WRSP based on literature. D - day; N - night; M - maternity colonies; H - hibernation.

Rock Crevices		Tunnels & Caves		Man-made Structures		Trees	
Antrozous pallidus (D)	Barbour & Davis 1969	Antrozous pallidus (H)	Alcorn 1944	Antrozous pallidus (D,N,W,M)	Barbour & Davis 1969 Beck & Rudd 1960	Lasiurus cinereus	Barbour & Davis 1969
Pipistrellis hesperus (D,M)	Barbour & Davis 1969 Cross 1965	Pipistrellis hesperus (H)	Alcorn 1944	Pipistrellis hesperus (N)	Cross 1965	Myotis volans (M)	Barbour & Davis 1969
Myotis volans (M)	Barbour & Davis 1969	Myotis volans (N)	Barbour & Davis 1969	Myotis volans (M)	Barbour & Davis 1969		
Eptesicus fuscus	Barbour & Davis 1969	Myotis lucifugus	Barbour & Davis 1969	Myotis lucifugus (D,N)	Barbour & Davis 1969		
Myotis californicus	Krutzsch 1954	Myotis evotis	Barbour & Davis 1969	Eptesicus fuscus	Barbour & Davis 1969		
		Eptesicus fuscus	Barbour & Davis 1969	Myotis californicus (M,N,D)	Barbour & Davis 1969 Krutzsch 1954		
		Myotis californicus (H,N)	Barbour & Davis 1969 Alcorn 1944	Myotis leibii	Barbour & Davis 1969		
		Lasionycteris noctivagans	Beer 1956				
		Plecotus townsendii	Barbour & Davis 1969				

Table 4.3-14

Habitat preferences of bat species found at WRSP based on literature.

Desert Shrub		Woodland-Forest		Riparian	
Antrozous pallidus	Barbour & Davis 1969 Jones 1965	Lasiurus cinereus	Jones 1965	Myotis californicus	Barbour & Davis 1969 Krutzsch 1954
Pipistrellis hesperus	Barbour & Davis 1969 Jones 1965	Myotis volans	Jones 1965		
Myotis californicus	Barbour & Davis 1969 Jones 1965	Myotis lucifugus	Whitaker et al. 1977		
		Myotis evotis	Barbour & Davis 1969 Jones 1965		
		Epesicus fuscus	Jones 1965		
		Lasionycteris noctivagans	Jones 1965		
		Plecotus townsendii	Jones 1965		

Total abundance and species richness for all sample periods from August, 1976 to August, 1979 are shown in Table 4.3-15. Both abundance and species richness peaked in June, 1978. The most abundant species from 1976 through 1979 are the pipistrel and the hoary bat in both June and August. Both species increased in abundance from 1976-1978 then began to decline in 1979 as did 7 of 10 species. Males dominated the sex ratios of all species in June while in most cases the sex ratios were nearly 1:1 in August.

The opportunistic foraging of most bat species causes abundance in an area to be largely dependent on the availability of prey species. The high mobility of bats enhances this response. If no unique roosting sites are in the area, population fluctuations may be assumed to be a response to food availability. Jones (1966) attributes seasonal changes in bat populations to change in water availability. As water becomes more scarce, bats concentrate. Bats use open water both for drinking and as foraging sites (insects tend to concentrate near open water in desert areas). Based on this information, the White River should support a large contingent of bats. Bat abundance peaks in early evening on the river, prior to cold air drainage which suppresses insect and bat activity. This effect can be extrapolated to yearly fluctuations in water availability and bat populations. However, without food-base data, explanations of population fluctuations are difficult.

Data on the reproductive condition of females were not collected. Thus, the presence of or absence of maternity colonies in the areas cannot be evaluated with certainty. However, the sex ratios in June favor males and those in August are nearly 1:1. This seems to indicate the lack of maternity colonies in the immediate areas.

Table 4.3-15

Species and abundance (number of individuals caught) of male and female bats at the Utah Oil Shale Tracts. June and August data are shown from 1976-1979.

	1976		1977				1978				1979				
	Aug		June		Aug		June		Aug		June		Aug		
SPECIES	M	F	M	F	M	F	M	F	M	F	M	F	M	F	Total
Little Brown Bat (Myotis lucifugus)	4	3	0	0	1	3	1	3	0	2	1	7	0	0	25
Long-eared Bat (Myotis evotis)	1	2	0	0	1	1	0	4	1	2	1	0	0	1	14
Long-legged Bat (Myotis volans)	2	3	1	0	0	0	2	2	4	12	4	3	0	3	36
California Bat (Myotis californicus)	3	1	0	0	0	0	7	2	0	0	1	0	2	2	18
Small-footed Bat (Myotis leibii)	0	0	0	0	0	0	11	3	1	0	7	0	0	0	22
Silver-haired Bat (Lasionycteris noctivagans)	0	0	7	3	1	0	10	0	1	0	7	0	1	0	30
Western Pipistrel (Pipistrellis hesperus)	4	4	12	6	14	6	21	7	25	18	2	1	2	2	124
Big Brown Bat (Eptesicus fuscus)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Hoary Bat (Lasiurus cinereus)	1	1	10	1	3	4	53	2	18	18	58	1	1	1	172
Pallid Bat (Antrozous pallidus)	0	1	0	0	1	0	9	1	2	1	1	1	1	1	19
TOTAL	15	15	30	10	21	14	115	24	52	53	82	13	7	10	461
Species Abundance	30		40		35		139		105		95		17		
Species Richness	7		4		6		10		8		9		7		

Total bat abundance and species richness fluctuations roughly correspond. This appears to be the result of the opportunistic nature of bat foraging. When conditions produce high insect abundance in the area, the bats' density increases in response to the availability of food. Some competitive interactions are indicated among bats on the tracts, but in years when food is abundant enough, competition for food would not affect the populations. Competitive interactions for other vital resources such as roost sites may, however, affect the bat community.

The population sizes of western pipistrels and hoary bats, the most abundant species, may be a result of habitat factors. The pipistrel is a desert bat that roosts in vertical crevices. The sandstone formations along the White River and sand canyons produce many vertical cracks due to the jointing properties of the rock. This may provide roost sites for a large population. The abundance of hoary bats, a tree roosting species, may be high due to the large areas of riparian vegetation along the White River provide roost sites (large cottonwood trees). Indeed, these bats were observed flying from the direction of the river in the evening and flying toward the river in the morning.

The status of roost sites for the other species is unknown. There appears to be no maternity roosts of noticeable size in the area. Availability of suitable hibernacula is reported to be low in Utah (Twente 1955, 1960). Consequently, most bats are likely to be summer residents; their populations responding primarily to food availability.

2. LAGOMORPHA

Two species of lagomorphs occur on the tracts, the desert cottontail (Sylvilagus audubonii) and the black-tailed jackrabbit (Lepus californicus). Jackrabbits are rare sightings having been observed in only two locations: the shadscale community in the southeastern corner of the tracts, and the juniper community near sampling site WJ-4. They are more abundant north of the tracts on the sagebrush-covered benches and interspersed juniper stands between Bonanza and Blue Mountain.

The desert cottontail is the common species on the tracts. Its population increased by 400 percent from 1975 to 1976 and has since steadily declined from 4.8 cottontails/km to 0.1/km in 1979, a substantial decrease in three years. Population trends in the cottontails followed a consistent pattern in 1975 and 1976, low in late winter and early spring, peaking in fall (Figure 4.3-17). In the drought of 1977 abundance declined to 2.8/km, but remained steady through the year. In February, 1978 cottontails seemed little affected by the winter. However, in April, their abundance declined drastically, recovered in June and has since declined to no cottontail sightings on transect during the last half of 1979. However, there are still a few present on the tracts.

Two-way Analysis of Variance testing cottontail abundance during five years in four habitat types showed 1976 as peak population and 1975 and 1979 as the low years ($p < 0.01$). This trend demonstrates a lag time in productivity which appears to be independent of primary plant production and precipitation. The cottontails did not respond to the desert bloom in 1975 until 1976, declined in number but remained steady during the drought, and markedly declined through 1978 and 1979. The main reason for

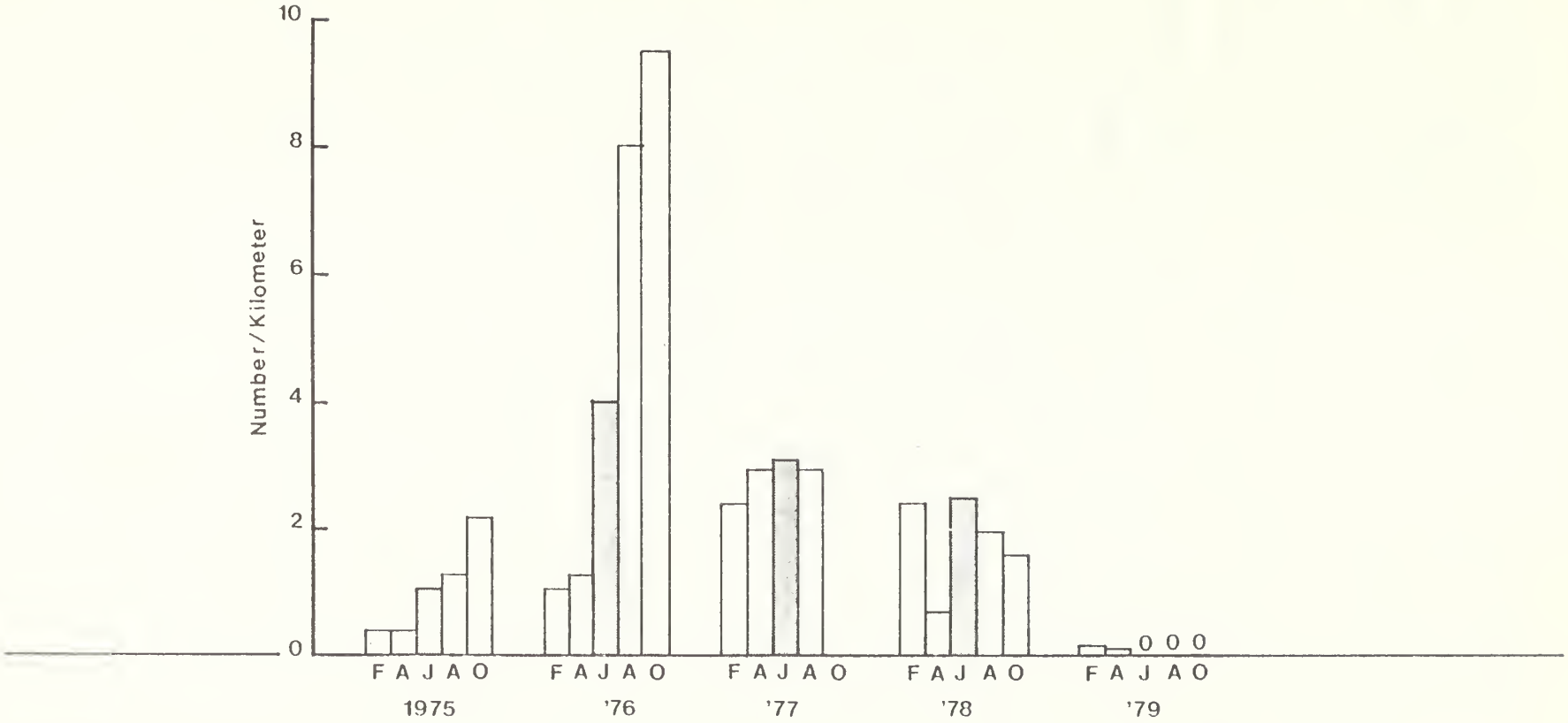


Figure 4.3-17. Monthly changes in cottontail (Sylvilagus spp.) abundance during five years on the Utah Oil Shale Tracts, Ua and Ub, in the Uinta Basin. Months of sampling = February, April, June, August, and October (no sample in October 1977)

the cottontail's moderate abundance through 1978 was the sagebrush-greasewood habitat. Abundance increased in this habitat in 1978 while declining in the other three communities. In 1979, cottontail abundance reached its peak in February.

Differentiation of populations among habitat types proved insignificant. As mentioned above, sagebrush-greasewood with its deep soils did maintain populations for the longest period through adverse climatic changes. The riparian habitat appears to be the second-most important habitat for the cottontail because of its food resources but not its shelter. Due to the moisture-laden soils along the river, shelter is found near and in the sandstone (escarpment) outcrop which bounds the riparian vegetation. Sandstone and shale outcrops are the prime burrow sites in shadscale and juniper habitats with a few burrows located in the washes where deeper soils have collected.

The cottontail's role as a prey item for carniverous birds and mammals is related only to red-tailed hawk (Buteo jamaicensis) populations. Both have fluctuated synchronously. It is definitely a prey item of the golden eagle (Aquila chrysaetos) which resides on the tracts. However, the eagles, whose populations have remained quite steady with the exception of a decline in 1977, apparently depend on the prey base found on the benches and basins north of the tracts. Since little reliable information is available for coyotes, the cottontail's role in their diet is unknown. It is known from personal communication with sheepmen in the area that coyotes are more of a problem in the area north of the tracts. For our own observations these benches maintain higher and more stable lagomorph

populations than the highly dissected tracts. As we have shown with the cottontails and will show with the rodents, a carnivore with limited mobility which must depend on such a widely varying prey base as found on the tracts would have definite problems maintaining a stable or high population.

3. RODENTIA

Twenty-two species of rodents inhabit the Oil Shale Tracts; seven members of the squirrel family (Sciuridae), three members of the seed-eating Heteromyidae, ten members of the gnawing Cricetidae, and one member each of the Castoridae and Erethizontidae. Two species were captured prior to our study and have not been captured since. The two species are the olive-backed pocket moust (Perognathus fasciatus), collected in Southam Canyon south of the White River, and the northern grasshopper mouse (Anychomys leucogaster), collected at the mouth of Hell's Hole Canyon. A third species which may be present is the Colorado chipmunk (Eutamias quadrivittatus).

Rodent densities through five years are somewhat similar to cottontail abundance. Densities were moderate in 1975, peaked in 1976, crashed rather than stabilized in 1977 and remained low in 1978-1979 (Figure 4.3-18). Densities in 1976 were significantly higher than all other years and 1975 densities were significantly higher than 1977-1979 densities ($p < 0.01$). As suggested in previous reports, rodents respond to environmental change with a one-year lag. Due to the precipitous crash during the drought and the lack of recovery during 1978-1979, it appears that peak density in 1976 was a carry-over from the magnitude of the 1975 bloom. Based on sagebrush and annual plant production during this same period (see Sec. 4.3.1)

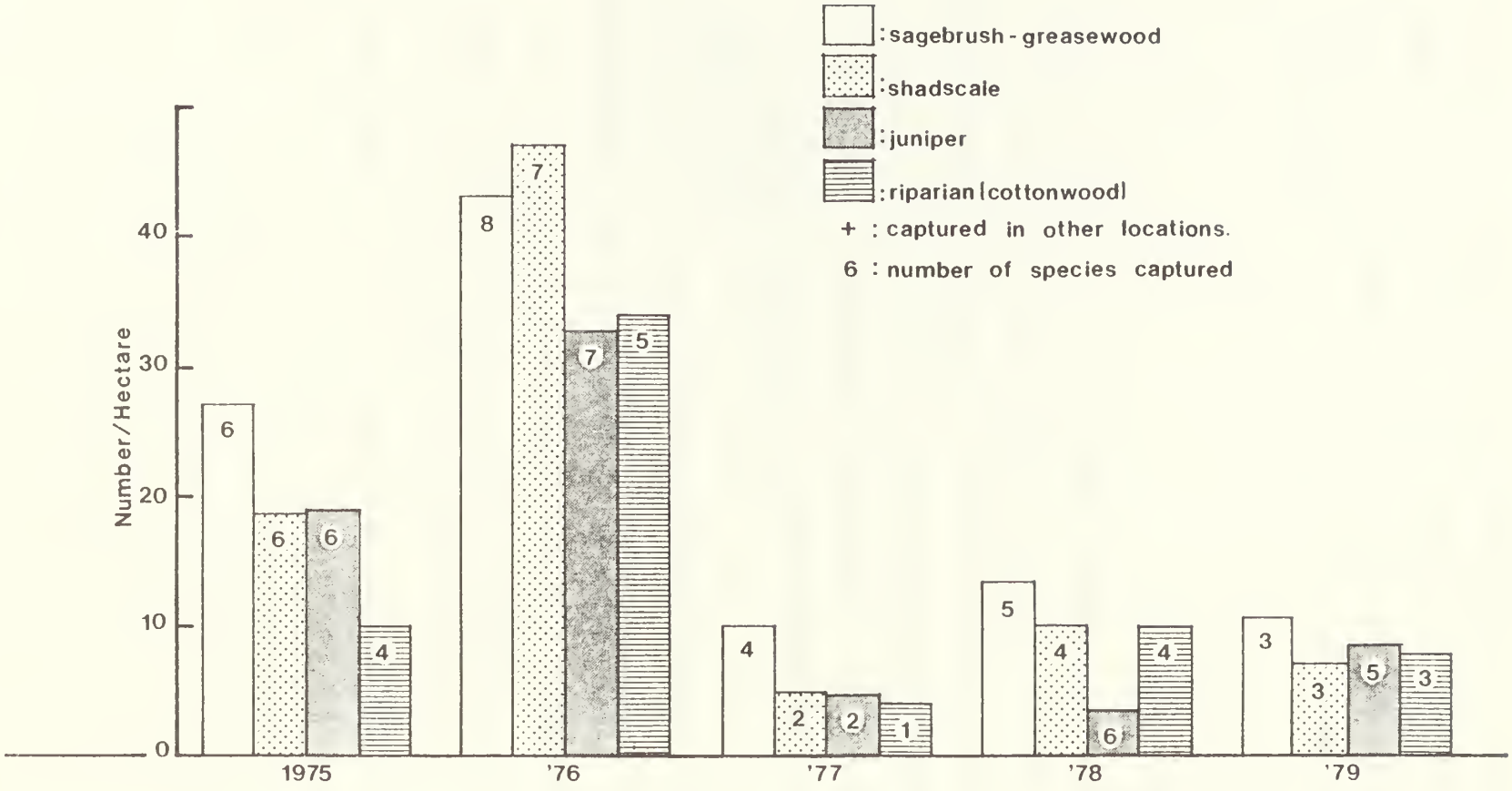


Figure 4.3-18. Rodent density and species richness in the four different habitats on the Oil Shale Tracts.

rodent density should have increased in 1975, 1978 and 1979 and decreased in 1976 and 1977. The peak in 1976 testifies to the magnitude of primary production in 1975. The absence of increasing density in 1979 is attributed to a dry spring and late summer rains which did increase sagebrush stem growth whereas annual production remained at the same level reached in 1978.

Species richness (the number of species present in a vegetation community) also peaked in 1976, significantly higher than all other years. Richness in 1977 and 1979 was significantly lower than all other years ($p < 0.01$). Species reichness followed density rather closely except in 1978 and 1979. In 1978, the spring precipitation pattern heralded increased primary production. By late May and early June the weather pattern became hot, windy and dry. By August rodent densities were depressed, however, species richness increased. In 1979, following a harsh, cold winter, the spring was warm and the summer hot. Density remained stable, and richness declined.

Within the four habitats, densities through five years were highest in the brush communities (sagebrush-greasewood, 21 rodents/ha; shadscale, 18 rodents/ha), lowest in the wooded communities (juniper, 14/ha; riparian, 13/ha). The wooded communities supported significantly lower densities than sagebrush-greasewood but not the shadscale ($p < 0.05$). Species richness which followed density on an overall basis, presented interesting variations when viewed from a community level. The riparian community with the lowest densities is the most sterile habitat in terms of richness (3 spp/yr) ($p < 0.01$). The only two species which occur with any degree of

consistency are the deer mouse (Peromyscus maniculatus) and the bushy-tailed woodrat (Neotoma cinerea). The woodrats reside in woodpecker holes in the snags. The deer mice reside in the sandy soils and in snags and heavy brush piles. The W soils which are wet year round and freeze in the winter are unusable by the burrowing mammals. Based on recaptures the mice appear to move through the lush vegetation, seldom staying in one location. It may be that these mice invade the riparian area from adjacent shadscale. Whatever the case, the deer mice body weights are significantly heavier than the body weights in the xeric communities ($p < 0.01$).

The other wooded community, the juniper, with its almost complete lack of understory and soils, supports a species rich rodent community at low density. Consistent residents are the least chipmunk, Apache pocket mouse (Perognathus apache), cañon mouse (Peromyscus crinitus), deer mouse, desert woodrat (Neotoma lepida) and bushy-tailed woodrat. Piñon mice (Peromyscus truei) invaded this area in 1976 and 1978 at measurable densities. Deer mice population explosions do not occur in the juniper as was depicted in the riparian woodland and will be evident in the brush communities. Apparently competition with the other rodents for food and shelter prevents this "weedy" species from dominating other rodent populations. In terms of biomass the two dominant species are the chipmunk and desert woodrat.

The two brush communities, sagebrush-greasewood and shadscale, are similar yet different. In terms of similarity, both supported distinct viable colonies of white-tailed antelope squirrels (Ammospermophilus leucurus) through 1976. Since the onset of the drought, these squirrels have gone

from rare sightings or captures to no sightings or captures. Their activity patterns were diurnal through 1976. Since then sightings were nocturnal. In 1978, the squirrels were captured again in the sagebrush-greasewood. In 1979 no squirrels were seen or captured on the tracts.

Both brush communities support relatively stable heteromyid populations. The densities of the pocket mouse and Ord's kangaroo rat (Dipodomys ordii) are lower in the shadscale yet more stabilized than densities in the sagebrush-greasewood. In the latter habitat, pocket mice are on the decline while kangaroo rats have remained steady. The heteromyids are the only rodents which have not been adversely affected by the extreme changes in climatic conditions. This strongly suggests that seed production and possibly seed catching is sufficient to maintain stable populations with the exception of the pocket mouse decline. Based on studies of seed selection by k-rats and pocket mice in other desert systems, the two species do not compete for food resource (Meserve 1976, Reichman 1975). Since pocket mice have remained stable in juniper and shadscale habitats, some unknown factor seems to be influencing these small mice in the sagebrush-greasewood.

The presence of both woodrats in both brush communities testifies to the high primary production during 1975 with its carry-over into 1976. Since the drought, woodrats have become rare captures, pointing out the fact that brush communities are marginal habitat for these large, gnawing rodents.

In terms of differences, the sagebrush-greasewood is the more productive of the two brush communities and does not show the extreme fluctuation seen in the shadscale, evident in the change from 30 deer mice/ha in 1976 to

0/ha in 1977 in the latter community. The shadscale community also supports a significantly lower species richness than juniper ($p < 0.01$) whereas the differences in juniper and sagebrush-greasewood richness was significant.

Seasonal abundance in rodents on the tracts clearly shows the increase in 1975, the peak in 1976, followed by the crash in 1977, recovery in 1978 and a lower abundance in 1979 (Figure 4.3-19). Rodent density and richness determined in August closely corresponds with rodent abundance from 1975-1978. In 1979 abundance and density do not show a clear relationship. Density at 8/ha compared to 9/ha in 1978 appears to be an overestimate when compared to average abundance of 11 rodents/100 trap nights in 1978 and 6/100 trap nights in 1979. Rodent populations and sagebrush stem growth were in close agreement until 1979 (see Sec. 4.3.1). Which factors affected the relationship are presently unknown.

Rodent community structure on the tracts is related to soil structure. Species richness is positively related to soil infiltration rate, and density is negatively related to percent moisture saturation (Figure 4.3-20). These soil characteristics reflect soil structure which is important in determining rodent burrowing, foraging, and ultimately, rodent community structure. While other factors such as primary production and competition are intuitively involved in structuring rodent communities, no other factors show significance with respect to rodent density and richness.

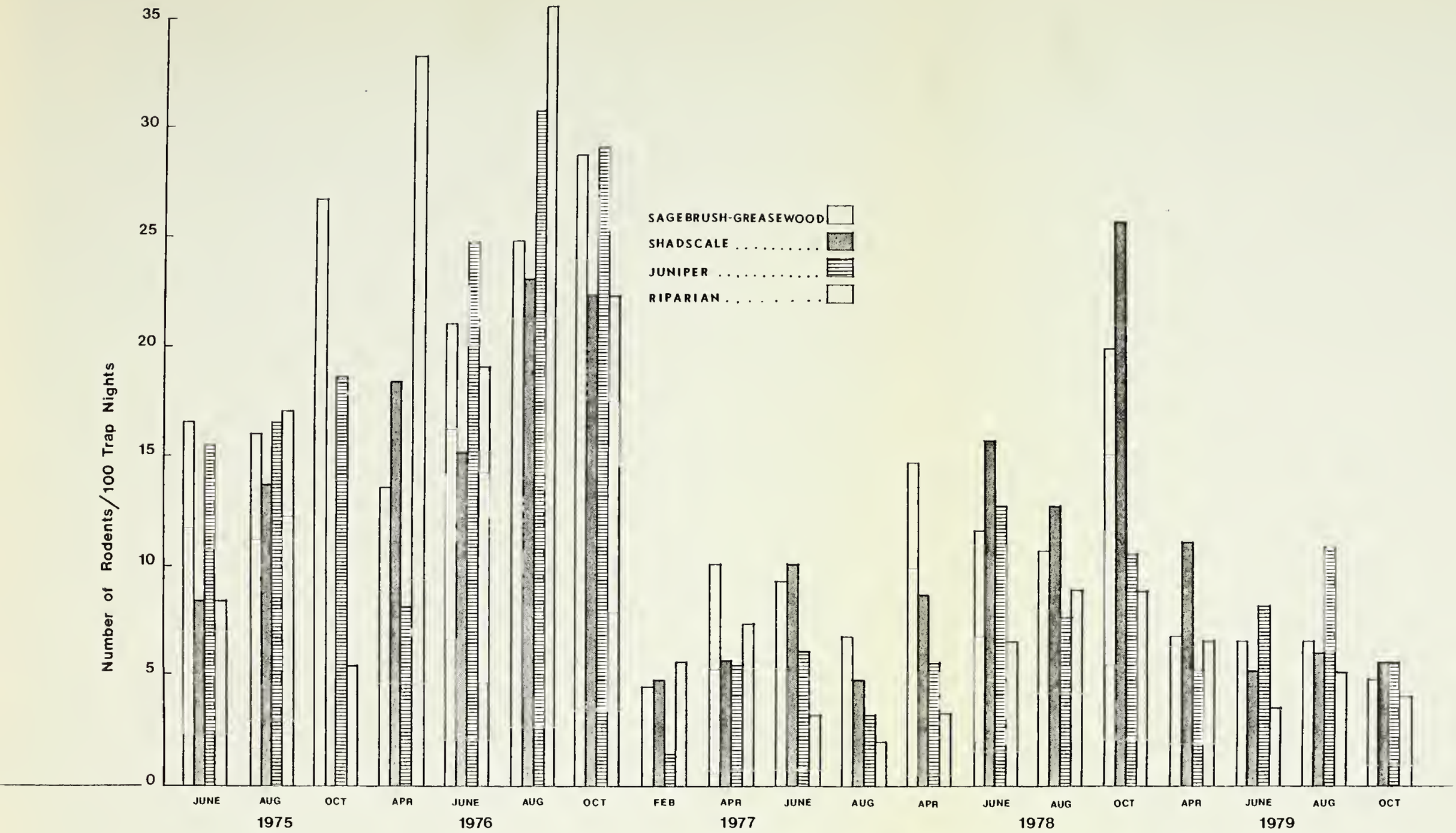


Figure 4.3-19. Rodent abundance (# captures/100 trap nights) in the four habitats for each sample period from June 1975 to October 1979.

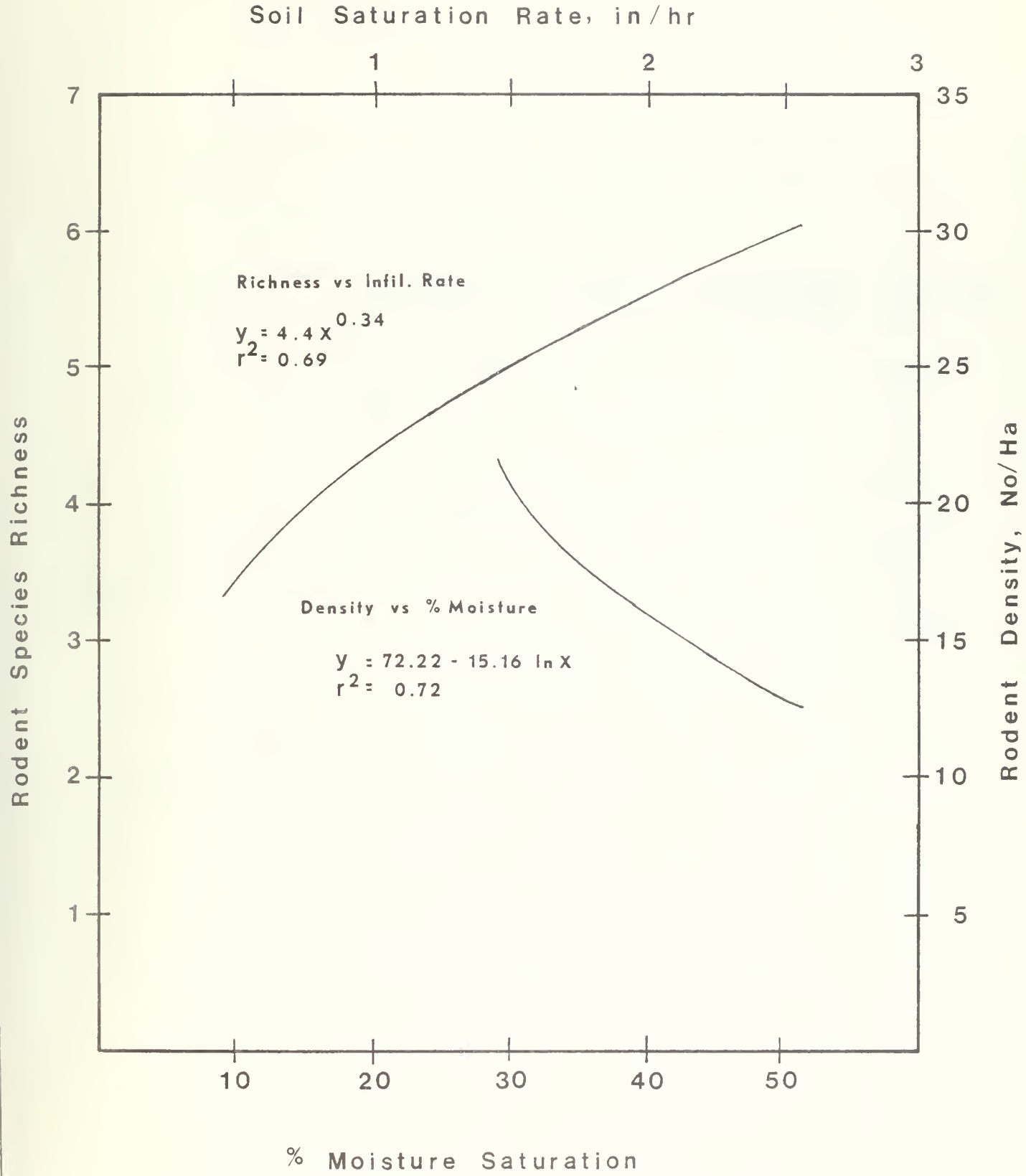


Figure 4.3-20. Rodent density (#/ha) and species richness vs soil infiltration rate and percent moisture saturation.

4. CARNIVORA

The eight members of this order that have been directly observed or indirectly observed by their calling, tracks or scat are listed in Table 4.3-16.

Coyotes (Canis latrans) as evidenced by their sign were the most plentiful carnivore and were observed in all habitats. The number of observations, though too few and infrequent to permit statistical analysis, were approximately equal between habitats. Total observations were approximately equal from year to year. In fact, coyote sightings on the tracts have been rare. The largest number seen in any year was three. Their calling was most pronounced during the spring and fall. The extent of the populations on the tracts is unknown.

One gray fox (Urocyon cinereoargenteus) was seen on the tracts in October, 1978 in the riparian habitat. They appear to be rare on the tracts and are probably of minor importance in the community. No evidence of red fox (Vulpes fulva) was observed in the area.

One long-tailed weasel (Mustela frenata) was observed on the tracts. This sighting occurred in the pinon-juniper habitat in June, 1976. No estimate of populations on the tracts can be made with the available data.

Badgers (Taxidea taxus) were seen in all habitats at different times. Sightings were few and are insufficient to estimate population size, habitat association, or role in the community. Burrows were found in the pinon-juniper habitat near sandstone outcrops and in the banks of the wash in Southam Cayon. They were observed to be active year-round which is consistent with Lindzey's (1971) observations.

Table 4.3-16

Order Carnivora, occurrence by habitat and year.

Species		Habitat G	Habitat J	Habitat S	Habitat R
Carnivora					
Coyote	1974				
	1975	+	+	+	+
	1976	+	+	+	+
	1977	+	+	+	+
	1978	+	+	+	+
	1979	+	+	+	+
Raccoon	1974				?
	1975				
	1976				
	1977				
	1978				
	1979				
Weasel	1974				
	1975				
	1976	+	+		
	1977				
	1978				
	1979				
Gray Fox	1974				
	1975				
	1976				
	1977				
	1978				+
	1979				

Species		Habitat G	Habitat J	Habitat S	Habitat R
Striped Skunk	1974				
	1975				+
	1976				
	1977				+
	1978				+
	1979				
Badger	1974			+	
	1975				+
	1976			+	
	1977	+	+		
	1978	+	+		
	1979			+	+
Lion	1974				
	1975			+	
	1976				
	1977				
	1978				
	1979				
Bobcat	1974				
	1975				
	1976	+			+
	1977				
	1978		+		
	1979				

Striped skunks (Mephitis mephitis) were only observed in the riparian habitat along the White River. Sightings were few and are insufficient to estimate population size or role in the community. Since sightings only occurred in the Cottonwood bottoms along the White River, they tend to support Ranck's (1961) opinion that the animal is most abundant in boreal habitats near a consistent source of water. Though expected to occur, there was no evidence of spotted skunks (Spilogale putorius) to date.

We have not observed mountain lions (Felix concolor) during the study to date. One individual, however, was seen by others just north of the White River near the wildlife sampling sites in 1975. Their presence cannot be discounted.

Bobcats (Lynx rufus) were seen or heard in the greasewood draws in the shadscale-juniper ecotone. They were also seen along the White River.

Ringtails (Bassaricus astutus) were not observed on the tracts during our study. Their presence is expected, however, as they were reported by Olsen (1973) and have been trapped in the area.

We have concluded that raccoons (Procyon lotor) do live in the area based on conversations with hunters and observation of a road kill in the Vernal area. Olsen (1973) reported that their presence along the White River was likely. There has been one unconfirmed report of raccoon tracks at the mouth of Hell's Hole Canyon.

There was no evidence of black bear (Ursus americanus) on the tracts although the shooting of a cub was investigated by UDWR personnel on Dead Man's Bench north of Bonanza.

No evidence of the presence of black-footed ferrets (Mustela nigripes) was seen. Mink (Mustela vison) were reportedly trapped along the Green and White Rivers and Willow Creek (Olsen 1973) although we have seen no sign of them.

River otters (Lutra canadensis) were not observed. Other than Durrant's (1952) report on an otter skin found near Ouray, no others were reported in the area although it is possible that they might use the White River periodically.

5. ARTIODACTYLA

Four members of the Artiodactyla are present or have been observed on the tracts (see Table 4.3-17).

Mule deer (Odocoileua hemionus), the most plentiful game species, were observed in all habitats, though in some years (1975-1977) they were not observed in brush habitats. During 1978 and 1979 they were observed in all habitats. Deer were observed in the riparian area in every year.

There has been a down trend in average total abundance since 1977 (see Figure 4.3-21). This reflects the decline from 1977 in mule deer harvest in the Book Cliffs District which includes the tracts. Precipitation data from the tracts has shown a downward trend from 1975-1978 which might explain the decline in deer abundance through a decline in primary production.

The highest average abundance has consistently occurred in the riparian community, followed by the juniper, shadscale, and sagebrush-greasewood. Analysis of variance by years and habitats at $\alpha =$ 0.05 shows no significant difference in abundance from year to year. Mobility of the animals seemed apparent during the dry year of 1977 when they shifted their use into the shadscale and juniper habitats at the expense of the riparian.

The decline in abundance in the riparian area could also have resulted from competition with livestock. Grazing usage by allotment remained

Table 4.3-17

Order Artiodactyla, occurrence by habitat and year.

Species		Habitat G	Habitat J	Habitat S	Habitat R	Species		Habitat G	Habitat J	Habitat S	Habitat R
Cattle	1974			+		Mule Deer	1974				
	1975			+	+		1975		+		+
	1976	⊕			+		1976	+	+		+
	1977	⊕			+		1977	+		+	+
	1978				+		1978	+	+	+	+
	1979				+		1979	+	+	+	+
						Pronghorn	1974				
Domestic Sheep	1974						1975				
	1975			+	+		1976				
	1976				+		1977				+
	1977		+	+	+		1978				
	1978	+	+	+	+		1979				
	1979	+		+	+						

Figure 4.3-21. Yearly mule deer abundance in the four habitats plus average abundance from 1975-1979.

nearly constant through all years in the riparian area. As precipitation influenced changes in primary production, the forage available to deer could have been reduced.

It has been estimated that about 150-250 mule deer use the tracts in spring, summer, and fall with about 50-100 present in winter. Fawn production was rated at 76% on the tracts while in areas south of the tracts in the Book Cliffs Resource Area in the years 1975-1978 fawn:doe ratios ranged from 66-75:100 (UDWR Report 1979).

No evidence of white-tailed deer (Odocoileus virginianus) were seen although it is rumored that they were seen in the Brown's Park area directly north of the tracts (verbal communication, DWR personnel). Neither elk (Cervus canadensis) nor moose (Alces alces) were seen on the tracts although they are present in nearby mountains. Bighorn sheep (Ovis canadensis) were not observed.

Pronghorn (Antilocpra americana) were sighted within the tracts once. During the 1977 drought, three were seen near the south shore of the White River. They are usually seen on the bench area north of the tracts and occasionally in the basin north of the mouth of Southam Canyon.

Grazing cattle are on and in the vicinity of the tracts from late June to October generally in the White River bottoms. Usage has remained fairly constant since 1973 at 450-480 animal unit months (AUM).

Domestic sheep (Ovis aries) are present on and in the vicinity of the tracts from December to April. Use in the Southam Cayon and Little Emma areas has increased from 1229 animal unit months (AUM) in 1973 to 3500 in 1979. Usage declined in Asphalt Wash during the same period from 2969 AUM to 1500 in 1978. In the Wagon Hound and Hell's Hole allotments, use has fluctuated over the years without a trend.

Birds

Fourteen species of birds were permanent residents on the tracts through five years of study. Forty species were summer residents and four species were winter residents. Transient species, those present during the spring and fall migratory seasons, numbered 12. Seventy-five species were found inconsistently at various times of the year (Table 4.3-18).

Yearly mean values for abundance and species richness (number of species on a site) are given in Table 4.3-19. The inconsistency between species richness and abundance suggests that the variance observed during the five years of study, is "normal." Species richness showed significant differences between years while species abundance showed no significant differences. Species richness was abnormally low during 1979.

Seasonal change in abundance and species richness is shown in Table 4.3-20. Analysis of variance and least significance difference (LSD) test indicated that June had significantly greater abundance than all other months with August abundance being significantly greater than February. All seasons had significantly different species richness values except April and August. This indicates that the number of species on the tracts changes significantly through the year and that in April and August similar numbers of species can be expected, however, actual species may differ.

Analysis of variance and LSD statistics show that the riparian habitat had significantly higher abundance and species richness than the other habitats samples, followed in order of significance by the sagebrush-greasewood, juniper, and shadscale habitats (Table 4.3-21). As abundance (mean values, 1975-1979) increases from the shadscale to the riparian habitat, species richness also increases. Hence, seasonal and habitat effects on abundance and diversity act in a similar manner on the tracts.

Table 4.3-18

Birds of the Utah Oil Shale Tracts, Ua and Ub, their habitat preference, seasonal occurrence and abundance, 1975-1979.

Habitat Preference

G - Sagebrush Greasewood
S - Shadscale
J - Juniper
R - Riparian

Habitat Preference Scoring

First habitat tested = 4
Second " " = 3
Third " " = 2
Fourth " " = 1

X = Present
- = Absent

	HABITAT PREFERENCE				ANNUAL ABUNDANCE, No/Km				
PERMANENT RESIDENT (n=14)	Winter	Spring	Summer	Fall	1975	1976	1977	1978	1979
Red-tailed Hawk [1]	R,G,J,S	R,S,J,G,	S,R,J,G	S,R,J,G	0.5	1.2	1.4	1.0	0.2
Golden Eagle	G,J,S,R	G,R,S,J	R,G,S,J	G,J,S,R	1.6	1.5	0.8	1.6	1.7
Marsh Hawk	S,G,J,R	S,G,R	S,G	S,G,R	0.4	0.1	X	X	X
Prairie Falcon	S,J,R	J,G	S,R,G,J	S,G,J,R	0.1	0.2	0.1	X	X
Great Horned Owl	J,R,G,S	R,J,S,G	R,J,S,G	R,J,S,G	X	X	2.2	1.7	0.2
Common Flicker	R,J,G	R,J,G	R,J,G	R,J,G	2.0	6.3	8.1	4.3	5.3
Hairy Woodpecker	R	R	R	R	X	0.6	1.0	1.7	0.7
Downy Woodpecker	R	R	R	R	1.8	1.1	1.6	0.9	0.1
Horned Lark	S,G,J,R	S,G	S	S,G,J,R	19.1	28.1	1.3	9.9	0.1
Scrub Jay	J,G	J,R,G	J,R,G	J,R	0.4	0.8	0.2	0.2	X

[1] Summer Resident, 1975 and 1976.

Table 4.3-18 (cont'd)

	HABITAT PREFERENCE					ANNUAL ABUNDANCE, No/Km			
PERMANENT RESIDENT	Winter	Spring	Summer	Fall		1975	1976	1977	1978	1979
Black-billed Magpie	R,G,J,S	R,G,S,J	R,G,J,S	R,G,J,S		6.9	9.4	9.9	16.2	9.8
Piñon Jay	J,G	J,G	J,G,S	J,G		43.4	38.2	7.6	33.0	55.5
Black-capped Chickadee	R	R	R	R,J,G		1.2	5.5	2.2	0.9	4.9
Plain Titmouse	J,G	J,G	J,G	J,G		1.5	4.1	1.0	4.6	0.4
Habitat Preference Score	J-33 R-32 G-29 S-17	R-36 G-28 J-27 S-16	R-37 J-24 G-23 S-23	R-35 J-32 G-28 S-21	Σ $\bar{x}$ SE	78.9 5.6 ±3.2	97.1 6.9 ±3.1	37.4 2.7 ±0.9	76.0 5.4 ±2.4	78.9 5.6 ±3.9
SUMMER RESIDENTS (n=40)										
Canada Goose	R	R	R	R		3.0	4.8	4.1	4.6	3.2
Turkey Vulture	-	R,S	R,S	-		3.8	1.9	0.1	X	0.9
American Kestrel	-	R,G,S,J	R,S,G,J	S,G		1.5	2.6	1.6	1.6	2.9
Killdeer	-	R,S	R,S	-		1.2	0.1	0.1	0.2	X
Spotted Sandpiper	-	-	R	-		2.8	3.8	1.3	0.6	0.1
Mourning Dove	-	R,G,S,J	R,J,G,S	R,S,G,J		28.1	6.8	4.5	4.5	7.0
Poor-will	-	-	J,G	J		X	X	X	X	X
Common Nighthawk	-	-	R,J,S,G	-		0.1	0.5	3.6	22.5	16.2
White-throated Swift	-	R	R,S,J,G	-		0.2	0.4	3.3	0.6	0.2

Table 4.3-18 (cont'd)

SUMMER RESIDENTS cont	HABITAT PREFERENCE				ANNUAL ABUNDANCE, No/Km				
	Winter	Spring	Summer	Fall	1975	1976	1977	1978	1979
Broad-tailed Hummingbird	-	R	R,J,S,G	-	0.1	0.9	0.5	0.8	X
Ash-throated Flycatcher	-	-	R,J,G	-	0.5	0.8	2.7	0.7	1.0
Say's Phoebe	S	R,G,S,J	G,R,J,S	-	2.7	3.2	2.3	1.6	2.6
Willow Flycatcher	-	R	R	-	0.3	0.1	0.7	0.6	0.3
Gray Flycatcher	-	J	J,G	-	2.0	1.5	1.5	1.9	3.2
Western Wood Peewee	-	-	R,J	-	1.0	X	1.2	0.6	0.6
Violet-green Swallow	-	R	G,R,S	-	1.3	0.5	X	0.3	0.5
Rough-winged Swallow	-	R	R,S,J	-	2.3	1.7	0.4	1.7	0.2
Cliff Swallow	-	-	R,S	-	52.0	6.3	2.7	30.8	16.8
Rock Wren	-	G,S,J,R	G,S,J,R	G,S,J,R	13.1	8.4	5.8	7.6	11.1
Sage Thrasher	-	S,G	S,G	S,G	2.2	1.8	0.4	0.3	1.5
American Robin	R,J	R,J,G	R	R	4.7	5.8	6.3	6.6	2.5
Western Bluebird	R,G	G,S,J,R	J,G,S,R	J,G,S,R	8.4	4.7	2.2	12.4	9.0
Blue-gray Gnatcatcher	-	R	R,J,G	R	2.2	5.0	6.0	3.6	2.0
Loggerhead Shrike[2]	S,G,J,R	S,G	S,G,J	S,G	3.0	5.4	1.7	2.4	1.1

[2]Permanent Resident, 1975 and 1976

Table 4.3-18 (cont'd)

	HABITAT PREFERENCE				ANNUAL ABUNDANCE, No/Km				
SUMMER RESIDENTS cont	Winter	Spring	Summer	Fall	1975	1976	1977	1978	1979
Starling	-	R,S	R,S	R,S	2.9	2.2	3.2	1.4	1.5
Warbling Vireo	-	-	R	-	0.3	0.6	0.9	0.1	0.2
Yellow Warbler	-	-	R	-	8.9	6.8	10.2	8.0	4.3
Black-throated Gray Warbler	-	R	J,G,R	-	2.3	1.9	1.6	0.9	2.8
Yellow-breasted Chat	-	-	R	-	2.1	2.0	1.4	1.3	1.3
Western Meadowlark	-	S,R,G	S,G,R	S,G	11.1	18.8	4.1	4.9	7.6
Northern Oriole	-	-	R	-	0.8	2.1	2.4	1.3	3.4
Brown-headed Cowbird	-	S	R,J	-	6.0	6.6	5.4	3.5	6.9
Blue Grosbeak	-	-	R	-	X	0.4	X	1.1	0.1
House Finch	-	R,J	R,J,G	R,J,G	6.8	19.5	26.7	11.6	43.1
Rufous-sided Towhee	-	R,J,G	R,G	R	15.4	9.0	3.3	4.5	3.6
Lark Sparrow	-	S	R,S,G,J	G	8.0	6.2	2.6	1.2	1.0
Black-throated Sparrow	-	G,J,S	G,J,S,R	-	7.2	7.8	6.3	3.9	3.9
Sage Sparrow	S	S,G	S,G	S,G,R	17.3	14.6	2.4	2.4	2.9
Chipping Sparrow	-	J,G,	J,G,R	J,G,R	9.7	5.0	1.4	0.1	2.8
Brewer's Sparrow	-	S,G,R	G,S,R,J	-	22.9	3.5	0.3	0.7	0.8

Table 4.3-18 (cont'd)

SUMMER RESIDENTS cont	HABITAT PREFERENCE Winter	Spring	Summer	Fall		ANNUAL ABUNDANCE, No/Km 1975	1976	1977	1978	1979
Habitat Preference Score	R-13	R-75	R-121	R-34	Σ	258.2	174.0	125.2	153.4	169.1
	S-12	S-51	G-65	G-33	x	6.5	4.4	3.1	3.8	4.2
	G-6	G-42	J-60	S-31	SE	1.6	0.7	0.7	1.0	1.2
	J-5	J-27	S-58	J-18						
TRANSIENTS (n=12)										
Mallard[3]	-	R	R	-		0.3	0.3	0.4	0.1	X
Green-winged Teal[3]	-	R	R	-		X	0.4	1.4	X	0.6
Common Merganser	R	R	-	R		0.1	0.1	0.1	0.8	X
Belted Kingfisher	-	R	-	R		X	0.3	0.2	0.4	X
Barn Swallow[4]	-	R	R,G	S,J,R		0.4	X	X	0.1	X
Ruby-crowned Kinglet	-	R	J,G	R,J,G		0.1	1.6	X	1.1	0.6
Yellow-rumped Warbler[3]	-	R	R,J,G	R,J,G		1.6	2.7	0.5	0.6	1.9
Red-winged Blackbird[5]	R	R	R	-		2.4	0.1	0.1	X	X
Brewer's Blackbird[3]	R	R,S	R,G,J,S	R		3.0	4.5	1.0	0.3	0.1
Vesper Sparrow	-	S,G	-	-		X	0.4	X	X	1.0

[3] May have nested in 1975 and/or 1976

[4] May have nested in 1977

[5] Nests at ponds in Asphalt Wash

Table 4.3-18 (cont'd)

TRANSIENTS cont	HABITAT PREFERENCE Winter	Spring	Summer	Fall		ANNUAL ABUNDANCE, No/Km 1975	1976	1977	1978	1979
Gray-headed Junco	-	R,G,J	-	-		X	X	1.2	X	0.2
White-crowned Sparrow	-	R,G,S	R	R,G,J		1.9	5.5	0.6	0.9	0.8
Habitat Preference Score	R-12	R-44	R-28	R-26	Σ	9.8	15.9	5.5	4.3	5.2
	G-0	G-9	G-11	J-11						
	J-0	S-9	J-9	G-7	$\bar{x}$	0.8	1.3	0.5	0.4	0.4
	S-0	J-2	S-1	S-4	SE	0.3	0.6	0.1	0.1	0.2
WINTER RESIDENTS (n=4)										
Bald Eagle	R,S	-	-	-		X	X	X	0.3	0.5
Common Raven[6]	G,R,J,S	J,R,G	J,G	-		0.7	2.8	0.9	3.1	1.9
Black Rosy Finch	R,J,G,S	-	-	-		X	43.8	12.0	1.0	X
Dark-eyed Junco	R,J	J,G,R,S	-	R,J,G		15.2	44.0	3.6	8.2	47.6
Habitat Preference Score	R-15	J-8	J-4	R-4	Σ	15.9	90.6	16.5	12.6	50.0
	J-8	R-5	G-3	J-3						
	G-6	G-5	R-0	G-2	$\bar{x}$	4.0	22.6	4.1	3.2	12.5
	S-2	S-1	S-0	S-0	SE	3.7	12.3	2.7	1.8	11.7
Total Habitat Preference Score, Consistent Species (n=70)	R-72	R-160	R-186	R-99	Σ	362.8	377.6	184.6	246.2	303.2
	J-46	G-84	G-102	G-70						
	G-41	S-77	J-97	J-64	$\bar{x}$	5.2	5.4	2.6	3.5	4.3
	S-31	J-64	S-82	S-56						

[6] Nested in Juniper, 1978

Table 4.3-18 (cont'd)

SUMMER RESIDENTS (inconsistent) (n=22)	HABITAT PREFERENCE				ANNUAL ABUNDANCE, No/Km				
	Winter	Spring	Summer	Fall	1975	1976	1977	1978	1979
Great Blue Heron	-	R	R	R	X	0.3	0.1	X	-
Cooper's Hawk[7]	S,G	R,G	R,J	R,S	0.4	0.2	0.1	0.2	-
Yellow-billed Cuckoo	-	-	R	-	-	-	0.2	-	-
Eastern Kingbird	-	-	R,G	-	0.2	0.1	-	-	-
Western Kingbird	-	G,S	R,J,S	-	0.2	0.2	-	0.1	X
House Wren	-	R	R	-	-	X	0.5	0.3	0.8
Bewick's Wren[8]	-	J,G,R	J	J,G	-	0.3	0.2	0.5	X
Long-billed Marsh Wren[9]	-	R	R	-	-	-	-	X	X
Canon Wren[10]	J,R	R	J,G,R	-	0.1	X	0.2	0.1	-
Mockingbird	-	-	G,S	-	-	1.5	-	-	X
Black-tailed Gnatcatcher	-	R	R,J,G	-	1.9	-	-	-	-
Solitary Vireo	-	-	R,J	-	0.5	-	0.8	0.3	0.1
Orange-crowned Warbler	-	R	R	-	0.4	-	0.1	0.5	0.2
Virginia's Warbler	-	-	R,G	-	1.6	-	-	-	0.2
MacGillivray's Warbler	-	-	R,G	-	X	0.1	-	-	-

[7] Permanent Resident, 1975, 1976

[8] May be transient, no June records

[9] Found only at ponds in Asphalt Wash

[10] Permanent Resident, 1976, 1977

Table 4.3-18 (cont'd)

SUMMER RESIDENTS (inconsistent) cont	HABITAT PREFERENCE					ANNUAL ABUNDANCE No/Km				
	Winter	Spring	Summer	Fall		1975	1976	1977	1978	1979
Common Yellowthroat	-	-	R	-		0.1	0.3	X	-	-
Wilson's Warbler[11]	-	R	R,G	R		0.7	0.1	-	-	-
Western Tanager	-	-	R,J,G	-		1.4	0.9	0.9	-	0.4
Black-hooded Grosbeak	-	-	R	-		1.8	0.3	-	-	0.3
Lazuli Bunting	-	-	R,J	-		3.2	0.8	0.2	-	-
American Goldfinch	-	-	R,J	-		X	1.5	0.9	0.5	-
Song Sparrow	R	R	R	R,G		X	X	X	-	X
Habitat Preference Score	R-7 J-4 S-4 G-3	R-38 G-10 J-4 S-3	R-78 J-29 G-23 S-5	R-16 G-6 J-4 S-3	n Σ $\bar{x}$	17 12.5 0.7	16 6.6 0.4	13 4.2 0.3	10 2.5 0.2	11 2.0 0.2
TRANSIENTS (inconsistent)										
Gadwall	-	R	R	-		X	X	-	-	-
Pintail	-	-	R	-		X	-	-	-	-
Blue-winged Teal	-	R	-	R		-	X	X	-	-
Cinnamon Teal	-	R	R	-		-	0.3	0.2	-	-
American Wigeon	-	-	R	-		X	-	-	-	-

[11] Transient, 1976

Table 4.3-18 (cont'd)

TRANSIENTS (inconsistent) cont	HABITAT PREFERENCE				ANNUAL ABUNDANCE, No/km				
	Winter	Spring	Summer	Fall	1975	1976	1977	1978	1979
Northern Shoveler	-	R	R	-	X	X	-	-	-
Sharp-shinned Hawk	J,G,S	J,S,R	R	R	-	X	X	X	0.2
Swainson's Hawk	-	-	G,S	-	-	X	-	-	0.1
Peregrine Falcon	-	G	R	-	X	-	-	-	-
Merlin	-	-	R	-	-	-	-	0.1	-
Chukar	-	-	S	-	-	-	X	-	-
Ring-necked Pheasant	-	-	R,S	-	-	X	-	-	-
Sandhill Crane	-	R	-	R	X	0.2	X	X	-
Whooping Crane	-	-	-	R	-	X	-	-	-
Virginia Rail[12]	-	R	-	-	-	X	-	-	-
Common Snipe	-	R	-	-	X	-	-	-	-
Greater Yellowlegs	-	R	-	-	-	0.1	X	-	X
American Avocet	-	R	-	-	X	X	-	X	-
Short-eared Owl	-	R,S	-	-	X	-	-	X	-
Black-chinned Hummingbird	-	-	R,J,G	-	X	-	-	-	X
Yellow-bellied Sapsucker	-	R	R	R	1.0	0.6	-	-	-

[12] Found only at ponds in Asphalt Wash

Table 4.3-18 (cont'd)

TRANSIENTS (inconsistent) cont	HABITAT PREFERENCE				ANNUAL ABUNDANCE, No/Km				
	Winter	Spring	Summer	Fall	1975	1976	1977	1978	1979
Eastern Phoebe	-	-	G	R	-	X	-	X	-
Western Flycatcher	-	-	R	-	-	X	-	-	-
Olive-sided Flycatcher	-	-	R	-	-	-	-	0.2	-
Tree Swallow	-	-	R	-	X	-	-	X	-
Common Crow	-	R	-	-	-	-	X	-	X
Clark's Nutcracker	-	-	-	J	X	-	-	-	-
Mountain Chickadee	-	-	-	J,R,G	-	1.4	-	-	0.4
White-breasted Nuthatch	R	-	R	-	-	0.1	0.7	X	-
Red-breasted Nuthatch	-	-	R,J	-	-	0.1	-	0.1	0.2
Brown Creeper	-	-	-	R	-	0.1	-	-	0.2
Hermit Thrush	-	-	R	R	-	X	-	0.1	0.1
Swainson's Thrush	-	-	R	R	0.1	X	-	-	0.2
Western Bluebird	-	R,J	-	-	C	-	0.4	-	-
Townsend's Solitaire	-	R,J,G	-	R	0.5	0.5	1.2	-	X
Water Pipit	-	R	-	R,J	X	0.1	-	-	X
Cedar Waxwing	-	-	R	-	0.1	3.1	1.8	X	-
Red-eyed Vireo	-	-	R	-	0.1	-	-	-	-

Table 4.3-18 (cont'd)

TRANSIENTS (inconsistent) cont	HABITAT PREFERENCE Winter	Spring	Summer	Fall		ANNUAL ABUNDANCE, No/Km 1975	1976	1977	1978	1979
Townsend's Warbler	-	-	R	-		-	-	-	1.1	0.1
Scott's Oriole[13]	-	-	G,J,R	-		0.1	0.1	0.1	-	0.2
Rose-breasted Grosbeak	-	-	J	-		-	X	-	-	-
Pine Siskin	-	G,R,J,S	-	R,G		0.1	-	-	-	0.4
Lesser Goldfinch[14]	-	-	R	-		-	X	-	-	-
Green-tailed Towhee	-	R,G	R	-		0.9	0.2	-	-	-
Lark Bunting[15]	-	-	S	-		X	-	-	-	X
Savannah Sparrow	-	S	-	-		-	X	-	-	-
Habitat Preference Score	R-4 J-4 G-3 S-2	R-69 G-13 J-12 S-11	R-94 G-14 S-14 J-13	R-51 J-11 G-5 S-0	n Σ $\bar{x}$	23 2.9 0.1	29 6.9 0.2	12 4.4 0.4	13 1.6 0.1	16 2.1 0.1
WINTER RESIDENTS (inconsistent) (n=7)										
Goshawk	R,J	-	-	R,J		0.2	0.2	0.3	0.3	-
Rough-legged Hawk	R,S,J,G	-	-	G		-	X	-	0.2	X
Long-eared Owl	R	-	-	-		X	X	-	-	-
Bushtit	J,R,G	J	-	R		2.1	0.2	-	X	-
Northern Shrike	R	-	-	-		-	-	-	-	0.1

[13] May have nested in 1976, 1979

[14] White River, east of Cowboy Canyon

[15] North of Bonanza, Dead Man's Bench

Table 4.3-18 (cont'd)

WINTER RESIDENTS (inconsistent) cont	HABITAT PREFERENCE Winter	Spring	Summer	Fall		ANNUAL ABUNDANCE, No/Km 1975	1976	1977	1978	1979
Gray-crowned Rosy Finch	R,J,G,S	-	-	-		X	X	-	-	-
Tree Sparrow	R	-	-	R		0.1	4.7	-	-	-
Habitat Preference Score	R-27	J-4	R-0	R-12	n	5	6	1	3	2
	J-12	R-0	J-0	G-4	Σ	2.4	5.1	0.3	0.5	0.1
	G-5	G-0	G-0	J-3						
	S-4	S-0	S-0	S-0	$\bar{x}$	0.5	0.8	0.3	0.2	0.05
Overall Habitat Preference Score, All Species	n=39	89	114	62	n	115	121	96	96	99
	R-110	R-267	R-358	R-178	Σ	380.6	396.2	193.5	250.9	307.4
	J-66	G-107	G-139	G-85						
	G-52	S-91	J-139	J-82	$\bar{x}$	3.3	3.3	2.0	2.6	3.1
	S-41	J-84	S-101	S-59						

Table 4.3-19

Species richness and abundance of birds on the Utah Oil Shale Tracts by year. Mean values for data from all habitats and seasons combined.

Year	Species Richness	# individuals per km
1975	25.6	20.4
1976	26.5	20.3
1977	23.9	13.3
1978	26.7	13.2
1979	18.7	21.8

Table 4.3-20

Species richness and abundance of birds on the Utah Oil Shale Tracts by season. Mean values for data from all habitats and years (1975-1979) combined.

Season	Species Richness	# individuals per km
February	10.1	9.8
April	27.3	15.8
June	36.8	32.2
August	26.7	17.7
October	17.5	12.6

Table 4.3-21

Species richness and abundance of birds on the Utah Oil Shale Tracts by habitat. Mean values for data from all seasons and years (1975-1979) combined.

Habitat	Species Richness	# individuals per km
Sagebrush-Greasewood	21.1	13.6
Shadscale	17.8	9.1
Juniper	19.0	11.5
Riparian	36.7	37.1

This suggests a common "cause" in both cases. The "cause" is probably structural complexity and productivity of the vegetation which is reflected throughout the primary and secondary consumer systems.

Habitat preference by species groups in shown in Table 4.3-18. Permanent residents favored the riparian most and the shadscale least. However, in winter more permanent residents preferred the juniper. This is probably because of the intense cold of the river valley. Overall, the woodland areas are most important to the permanent residents.

Summer residents strongly favored the riparian habitat while the juniper and shadscale habitats were least preferred. This is probably due to the high temperatures, low productivity, and scarce water in the juniper and shadscale areas. Transients show a similar pattern.

Winter residents are found most often in the riparian areas during the fall and winter. However, during spring and summer they are often seen in the juniper habitat. Shadscale is least favored.

The riparian habitat appears most important to game birds of all habitats on the trcts. The chukar which prefers xeric areas was reported in the shadscale area.

Most raptors use the riparian habitat at some time during the year. Many species use the cottonwood trees for roosts and nesting. The surrounding brush habitats are important foraging areas for many species, and a few species (e.g., kestrels and golden eagles) next in these areas.

Obligate species, those birds encountered exclusively in one habitat, are numerous in the woodland habitats, primarily the riparian-cottonwood and scarce in the brush habitats. Seventeen species reside along the White River; four reside in the juniper. The six species in shadscale and

sagebrush-greasewood would have been lumped in both communities had our information been confined to 1975-1976. The 27 obligate species and their habitat associations are listed in Table 4.3-22.

In terms of exclusive obligates, the riparian birds meet the definition most precisely. Without the riparian habitat, its trees, beaches, brush, grasses and the river itself, these birds would be eliminated. In fact, destruction of the riparian community would adversely affect the populations of 27 other consistent species, 18 inconsistent summer residents, 33 inconsistent transients, and 6 inconsistent winter residents, 101 total species or 69 percent of the avifauna found on the tracts.

The four obligate species of the juniper community use the adjacent sagebrush-greasewood for foraging whereas nesting is confined to juniper trees and in the case of the black-throated gray warbler (*Dendroica nigrescens*) to sagebrush interspersed among the trees. The six obligate species in the brush communities are listed in their respective habitats based on data from 1977-1979 when population declines and climatic conditions clearly defined preferences. Some overlap still occurs between these communities; nevertheless, abundance for the black-throated sparrow (*Amphispiza bilineata*) is highest in sagebrush-greasewood and likewise in shadscale for the other five species. The western meadowlark (*Sturnella neglecta*) which is not included nested exclusively in the shadscale during 1978-1979. Prior to this time the sagebrush-greasewood and riparian communities provided adequate habitat for this species.

Three endangered species have been sighted on the tracts. These are discussed more fully in Section 4.3.2.4. Bald eagles use the riparian areas of the White River extensively during the winter. While they are primarily found along the White River corridor, they also forage in brush areas.

Table 4.3-22

Obligate avian species, their residency status and habitat association on the Utah Oil Shale Tracts, Ua and Ub.

PR - Permanent Resident
SR - Summer Resident
WR - Winter Resident
T - Transient

HABITAT TYPE & STATUS		HABITAT TYPE & STATUS	
Riparian-Cottonwood		Riprian-Cottonwood (continued)	
Canada Goose (Branta canadensis)	SR	Northern Oriole (Icterus bullockii)	SR
Mallard (Anas platyrhynchos)	T	Blue Grosbeak (Guiraca caerulea)	SR
Green-winged Teal (Anas carolinensis)	T	Juniper	
Common Merganser (Mergus Merganser)	T	Piñon Jay (Gymnorhinus cyanocephala)	PR
Bald Eagle (Haliaeetus leucocephalus)	WR	Plain Titmouse (Parus inornatus)	PR
Spotted Sandpiper (Actitis macularia)	SR	Gray Flycatcher (Empidonax wrightii	SR
Belted Kingfisher (Megaceryle alcyon)	R	Black-throated Gray Warbler (Dendroica nigrescens)	SR
Hairy Woodpecker (Dendrocopus villosus)	PR	Shadscale	
Downy Woodpecker (Dendrocopus pubescens)	PR	Marsh Hawk (Circus cyaneus)	PR
Willow Flycatcher (Empidonax trailii)	SR	Horned Lark (Eremophila alpestris)	PR
Cliff Swallow (Petrochelidon pyrrhonota)	SR	Sage Thrasher (Oreoscoptes montanus)	SR
Black-capped Chickadee (Parus atricapillus)	PR	Loggerhead Shrike (Lanius ludovicianus)	SR
Warbling Vireo (Vireo gilvus)	SR	Sage Sparrow (Amphispiza belli)	SR
Yellow Warbler (Dendroica petechia)	SR	Sagebrush-Greasewood	
Yellow-breasted Chat (Icteria virens)	SR	Black-throated Sparrow (Amphispiza bilineata)	SR

Reptiles

1. Snakes

The western yellow-bellied racer (Coluber constrictor) was found in all years in low numbers (1-4), occurring exclusively in the riparian area (see Table 4.3-23). Data are insufficient to estimate the population. The racer is encountered most often in grassy areas near the river and in leaf litter and grass beneath old cottonwood stands. The racer is the most commonly encountered snake in the riparian area.

The whipsnake (Mastcophis taeniatus) was observed in equal numbers (3-5 years) in the sagebrush-greasewood, shadscale and riparian communities. None were observed in the pinon-juniper community. They were observed in each year although they were not seen in the sagebrush-greasewood community during the dry years of 1976 and 1977 nor in the riparian community during 1977 and 1978. They generally occur in the more brushy habitats.

Gopher snakes (Pituophis melanoleucus) were found primarily in the riparian area and were present in all years. In 1978 they were found for the first time in the pinon-juniper and shadscale communities. The gopher snake is the most abundant snake on the tracts. Sightings have average 2-4 per year along the tracts.

The wandering garter snake (Thamnophis elegans vagrans) was seen exclusively in the riparian community during 1975 and 1977. The maximum number observed was two in any year. Following 1977, the dry year, the garter snake was not seen.

Two other colubrids are known to inhabit the basin; the milk snake (Lampropeltis triangulum) and the night snake (Hypsiglena torquata) (Tanner (Tanner 1957, Olsen 1973). They have not been observed to date.

Table 4.3-23

Order Squamata, occurrence by habitat and year.

Species		Habitat G	J	S	R	Species		Habitat G	J	S	R
Northern Whiptail	1974					Short-horned Lizard	1974				
	1975	+	+		+		1975			+	
	1976	+	+		+		1976			+	
	1977	+	+	+	+		1977	+		+	
	1978	+	+	+	+		1978			+	
	1979	+	+	+	+		1979			+	
Northern Side-Blotched Lizard	1974					Western Yellow-bellied Racer	1974				
	1975	+	+	+	+		1975				+
	1976	+	+	+	+		1976				+
	1977	+	+	+	+		1977				+
	1978	+	+	+	+		1978				+
	1979	+	+	+	+		1979				+
Tree Lizard	1974					Midget-faded Rattlesnake	1974				
	1975		+				1975	+			
	1976		+		+		1976	+	+		
	1977		+		+		1977	+			
	1978		+	+	+		1978	+			
	1979		+	+	+		1979	+			
Northern Sage-Brush Lizard	1974					Striped Whipsnake	1974				
	1975	+	+	+	+		1975	+			+
	1976	+	+	+	+		1976				+
	1977	+	+	+	+		1977			+	
	1978	+	+	+	+		1978	+		+	
	1979	+	+	+	+		1979				+

The midget faded rattlesnake (Crotalus viridis concolor) was observed principally in the sagebrush-greasewood community. A single sighting occurred in the pinon-juniper. Within the sagebrush-greasewood community the number of encounters per year was nearly equal (1-2).

Snake abundance is low based upon the number of encouters in the field (see Figure 4.3-22). Abundance was highest during the relatively "wet" year of 1975 but declined sharply during 1976 and 1977 probably reflecting a drop in rodent density during those years. With increased precipitation in the past two years, encounters have become slightly more frequent.

A regression of abundance in a particular habitat versus average abundance for the years 1975-1979 shows the riparian habitat to have the highest correlation ($r = 0.86$) with average abundance. Shadscale and sagebrush-greasewood communities had r's of 0.80 and 0.79 respectively. There was a weak vegetative correlation between snake abundance in the pinon-juniper community and total abundance. The only significant correlation ($\alpha = 0.05$) was in the riparian community.

2. Lizards

Among species, during the five years the northern sagebrush lizard had the highest average abundance at 1.95/km followed by the side-blotched lizard at 0.96/km, northern whiptail at 0.81/km, northern plateau lizard at 0.27/km and the tree lizard at 0.09/km (see Figure 4.3-23). Two way ANOVA indicated that there was a significant ($\alpha = 0.05$) difference in average numbers between species through the five years. Fishers' LSD test showed the northern sagebrush lizard to be the most abundant followed by the northern whiptail and northern side-blotched lizards which were not significantly different in numbers. The least abundant were the tree and northern plateau lizards.

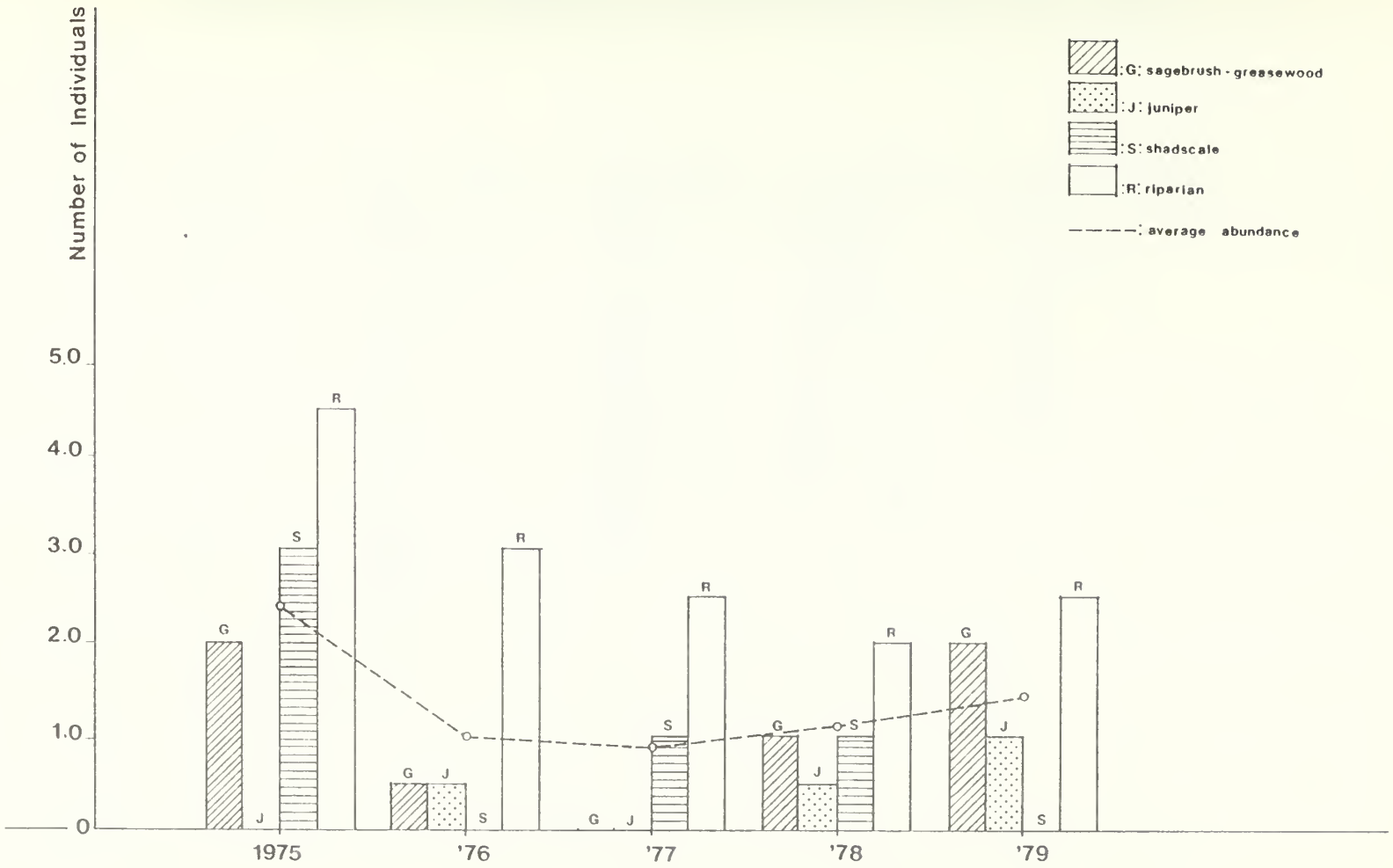


Figure 4.3-22. Snake abundance on the Utah Oil Shale Tracts. Yearly total values for each habitat and yearly mean values for all habitats (dashed line).

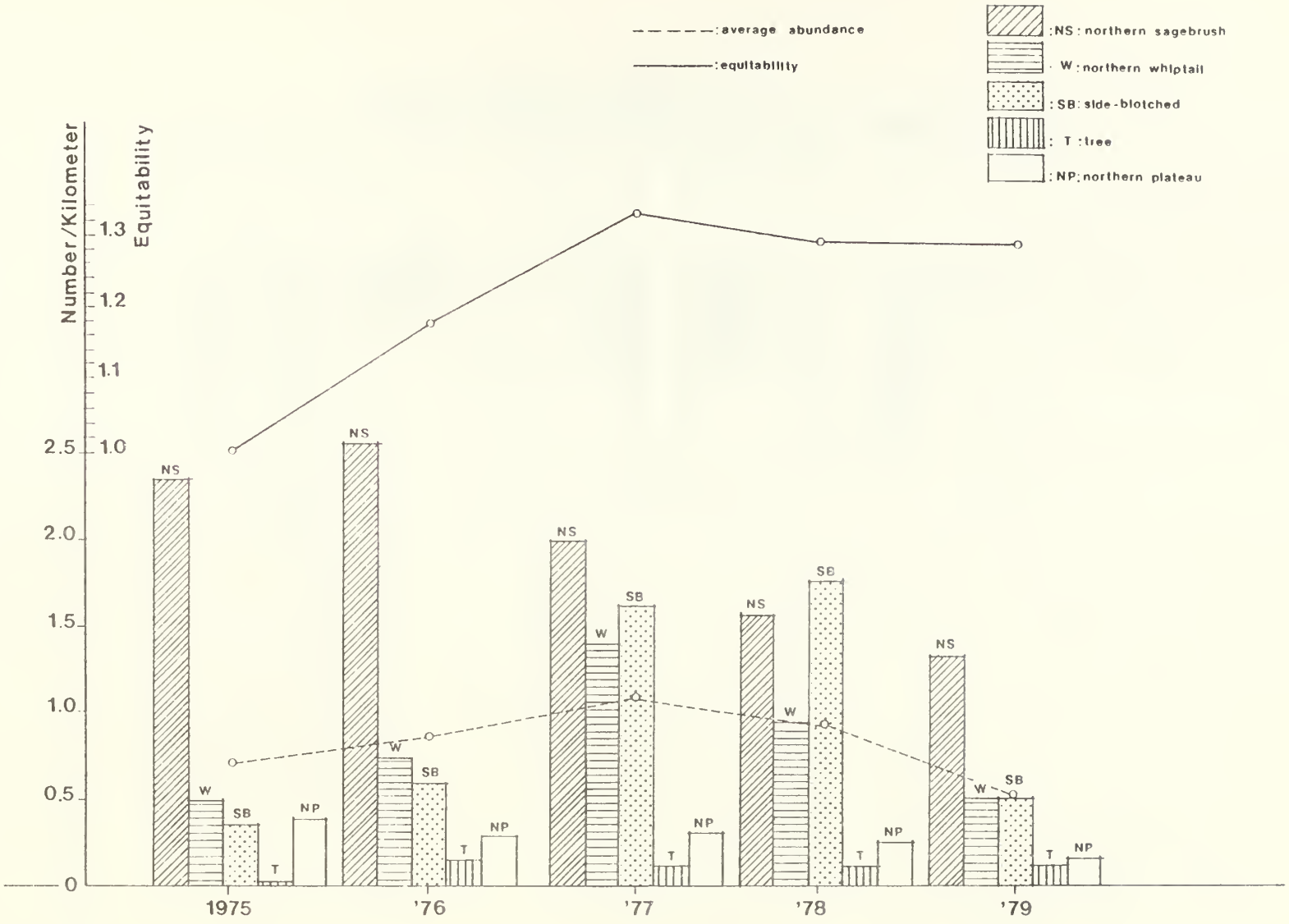


Figure 4.3-23. Lizard abundance on the Utah Oil Shale Tracts. Yearly mean values for each species and overall yearly mean values.

Overall average abundance of five species rose from 0.72/km in 1975 to 1.08/km in 1977, then declined to 0.52/km in 1979 (See Figure 4.3-24). With the exception of 1977 the juniper habitat had the highest average abundance during all years. Overall abundance averaged 0.82/km for the four habitats combined for all five years. Juniper overall abundance averaged 1.19/km, followed by shadscale at 0.764/km, sagebrush-greasewood at 0.764/km, and riparian at 0.554/km.

Two-way ANOVA indicated that there was no significant difference in lizard abundance from year to year, but that there was a significant difference in abundance between habitats. Fishers' LSD test indicates, however, that average abundance in 1979 was significantly less that all other years and that the average abundance in juniper was significantly higher than all other habitats. Average abundance was not significantly different among all other habitats or years.

The Shannon-Wiener information index ($H' = - \sum p_i \log p_i$) applied to the abundances gave a value of 1.3 ± 0.03 SD with a minimum of 1.27 and maximum of 1.35 (see Figure 4.3-24). This means that the relative proportions of abundance were consistent from year to year with little change, i.e., no major shift of overall lizard abundance from one habitat to another occurred in any year. The only shift noted of any significance occurred in 1977 when abundance increased in the shadscale habitat to the largest of the four habitats. This shift was the result of the new transect in the shadscale.

Overall species diversity calculated using the Shannon-Wiener index on species abundances (see Figure 4.3-23), increased from 1.02 in 1975 to 1.33 in 1977, then leveled off at 1.28 in 1978, 1979. The increase in diversity during the dry year of 1977 reflected a decrease in dominance of the northern sagebrush lizard with increases in the relative proportion of whiptails and side blotched lizards.

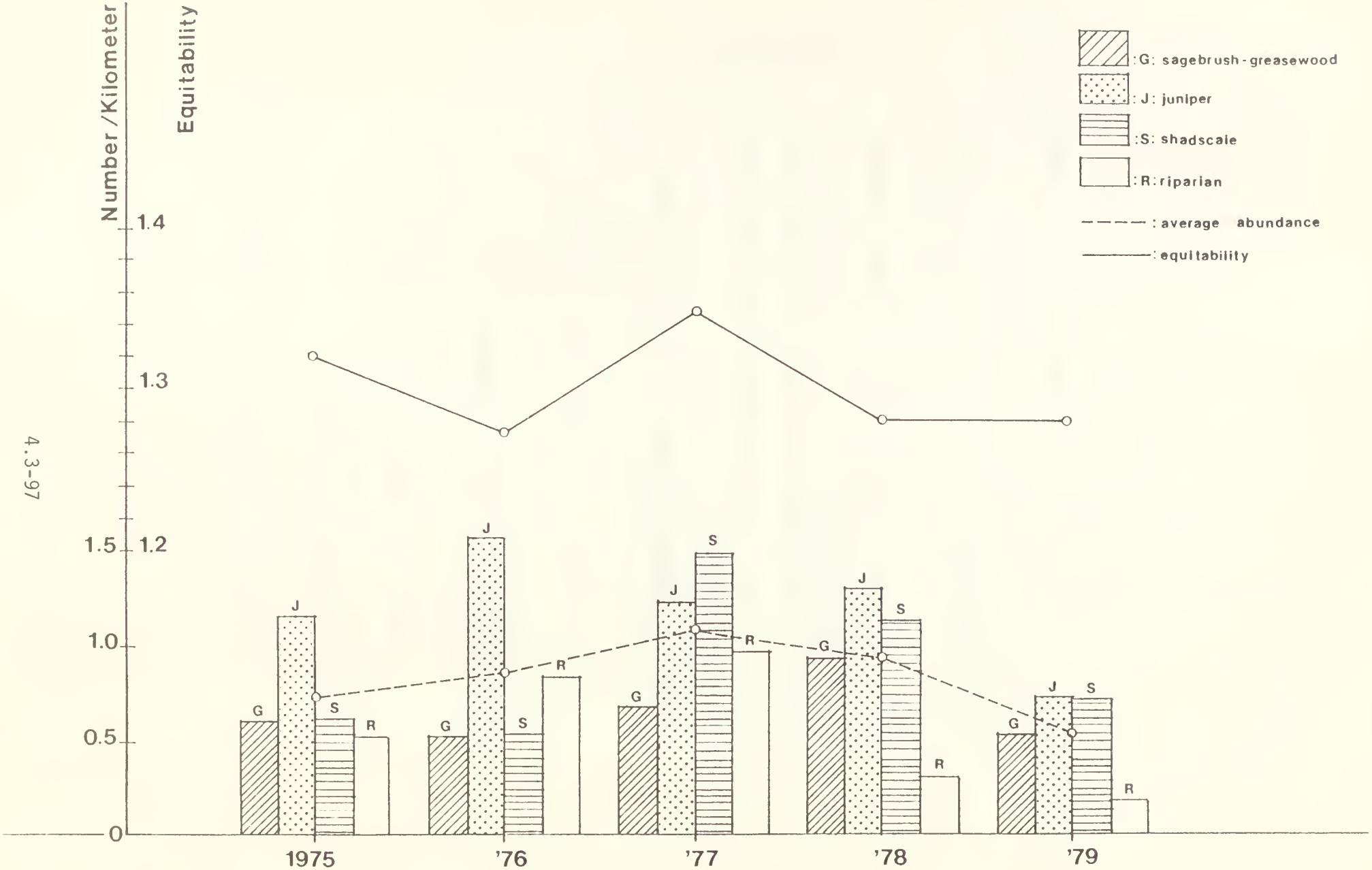


Figure 4.3-24. Annual abundance for all lizard species by habitat. Mean values for each habitat and mean values for all habitats (dashed line) from 1975-1979.

4.3.2.4 Threatened and Endangered Species. Due to the presence of a white-tailed prairie dog town in the one mile boundary area adjacent to the tracts, the blackfooted ferret (*Mustela nigrens*) could be present. The town is located north of the White River and is not likely to be directly impacted by mining. The prairie dog population became extinct in 1978. Consequently, the presence of ferrets is doubtful.

The first endangered bird species is the whooping crane (*Grus americana*). During the fall migration in 1976, one crane was sighted flying south over the tracts in the company of approximately 300 sandhill cranes (*Grus canadensis*). This crane is most likely one of the birds experimentally raised at Gray's Lake, Idaho. Its occurrence on the tracts would be limited to the riparian habitat and the presence of sandhill cranes with which they migrate. A few of the sandhill cranes are known to use the river bottom for overnight rest stops, and one pair during the spring appeared to spend a few days in the area. The number of sandhills which migrate over the tracts each spring and fall exceeds 3,000. The probability of whooping cranes using the river bottom is low, however, the possibility of their presence cannot be denied.

Of the two endangered birds which has been encountered directly on the tracts, the peregrine falcon (*Falco peregrinus*) may have nested in 1975 only, and the bald eagle (*Haliaeetus leucocephalus*) is a consistent and relatively numerous winter resident along the White River.

Confirmed sightings of the falcon occurred in April and August, 1975. The spring sighting was made in Wagon Hound Canyon north of the tracts. The summer sighting occurred near one of the wildlife transects on the White River. The latter encounter strongly suggests that the falcon nested in the area. Since the birds were not observed in June, it could be they

were migrating. The sightings do suggest that high avian abundance may be indicative of the falcon's presence in the area.

The bald eagle is a consistent winter resident along the White River, ranging from east of Meeker, Colorado to Ouray, Utah. The eagles forage along the river and in the adjacent shadscale habitat as far north as Bonanza, Utah, and along Evacuation Creek to the south. The earliest sighting on the tracts was December 1975, the latest February, 1978. Records are also available of October, 1974, and February, 1975 sitings. The sandstone cliffs along the river corridor and cottonwood snags in or near the river are the preferred roosting sites. Peak abundance in the riparian habitat occurred in 1979 at 0.5 eagles/km. The number of bald eagles which use the river within or near the tract boundaries ranges from 3-10 during the winter.

Form 1279–3
(June 1984)

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